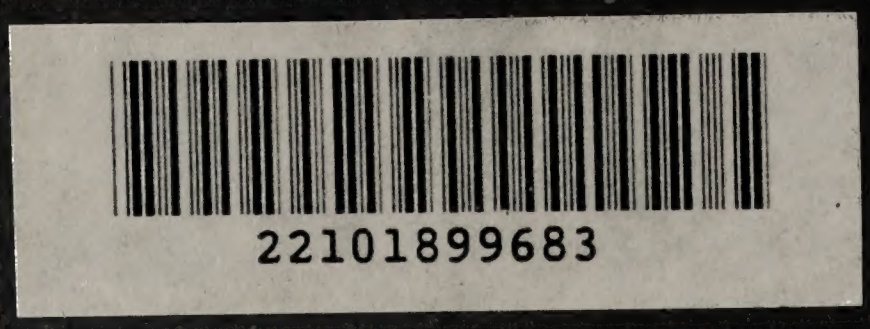
MILITARY HYGIENE

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THE

THEORY AND PRACTICE

OF

MILITARY HYGIENE

BY

EDWARD L. MUNSON, A.M., M.D.

Captain, Medical Department, United States Army

ILLUSTRATED BY EIGHT PLATES AND NEARLY FOUR HUNDRED ENGRAVINGS

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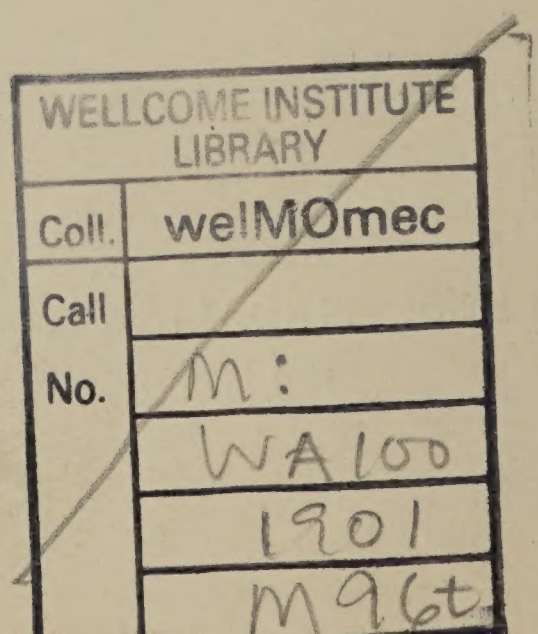
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To

BRIGADIER-GENERAL GEORGE M. STERNBERG

Surgeon-General, United States Army

WHOSE PROFESSIONAL LABORS HAVE SO MATERIALLY CONTRIBUTED TO THE ADVANCEMENT OF SANITARY SCIENCE, AND WHOSE OFFICIAL ADMINISTRATION HAS SO GREATLY PROMOTED THE WELFARE OF THE ARMY AND THE EFFICIENCY OF THE MEDICAL DEPARTMENT

This Book

IS RESPECTFULLY DEDICATED BY THE AUTHOR

IN GRATEFUL APPRECIATION OF MANY ACTS OF KINDNESS

PREFACE.

For the preparation of a work on the subject of military hygiene, the author has no apologies to offer. Save a small collection of sanitary precepts, intended for the use of officers of the line, no book exclusively devoted to the preservation of the health of troops has been published in the English language in more than a generation. The more complete works on general hygiene contain much material which has no applicability to the military service, and, on the other hand, they leave unnoticed a large number of subjects a knowledge of which is of the highest importance to the military sanitarian. For these reasons, many of the lessons learned by bitter experience in camp and garrison, during a period in which sanitary science has made its greatest progress, have been practically lost to medical officers of the present day, and the experience of the past few years has demonstrated the need of a text-book dealing directly with the sanitary problems peculiar to the military service. This it has been the endeavor of the author to supply in the present volume, which it is hoped will be found available not only as a book of reference for medical officers, in connection with their sanitary duties, but also as a practical guide to officers of the line, with respect to the care of troops over whom they have control. In view of the fact that this book is intended for use under conditions in which recourse to a library of reference will rarely be practicable, it has been thought best not to increase the size of an already large volume by including a bibliographical index of the authorities, some twenty-seven hundred in number, referred to in the text or consulted in its preparation. A list of these authorities has, however, been preserved, and may be placed at the disposal of those who desire to go more fully into the vast subject of military hygiene.

In conclusion, the author desires to express his great indebtedness to Colonel Charles Smart, Assistant Surgeon-General, United States Army, at whose suggestion and through whose kindness the preparation of this work was undertaken, and whose encouragement and assistance rendered its completion possible. Possessed of an infinite knowledge of sanitary affairs, it is the misfortune of the military service that pressure of public business made it necessary for him to delegate the writing of this book to a less worthy pen.

The author has received much valuable aid from his wife in the preparation of notes and of the index.

E. L. M.

Washington Barracks, D. C., January 1st, 1901.

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THE

THEORY AND PRACTICE OF MILITARY HYGIENE.

CHAPTER I.

THE SELECTION OF THE RECRUIT.

RECRUITMENT being the first necessity in the organization of military forces the examining officer should bear in mind that upon the faithfulness and intelligence with which his duties are performed depend in great degree the future health, efficiency, and mobility of an army. He should consider that war and not peace affords the theoretically normal conditions governing the military establishment, that physically sound troops are essential to success both in sudden emergencies and prolonged campaign, and that the soldier may be called upon at any time to sustain the maximum of fatigue and privation of which the human being is capable. According to the first Napoleon, "the most important quality of the soldier is his ability to support fatigue and privation; physical courage is only the second"—and it should not be forgotten that the effectiveness of a force depends upon its vigor rather than upon its size. The strength and health of a military organization is based upon the physical character of the individuals composing it, and celerity of movement and the ability to bear hardship are imperatively demanded in the successful manipulation of armies. Recruits must be of trustworthy physique and sound constitution before the military character can be developed, and the physically, mentally, and morally defective are hence to be uniformly rejected as unfit for service. Perfunctory performance of duty or inattention in this respect will often admit as recruits men whose physical faults render them unfit for duty and susceptible to disease, whose undetected affections may be transmitted to others or whose moral obliquities induce malingering and desertion. Such defects will early become evident in the company organization, and the eventual discharge of the soldier on account of pre-existing disability cannot fail to bring discredit on the skill and carefulness of the examiner. Little argument seems required to demonstrate the necessity for careful physical examination before enlistment; but it may be well to remember that during the war with Mexico the regular troops, who bore the brunt of the campaign, lost about two-thirds as many from disease and by discharge for disability as did the volunteer troops, the former having been physically examined where the latter had not. In the Civil War the annual mortality from disease was 32 per 1,000 in the case of the regular army, and 55 per 1,000 from the less carefully examined volunteers. At the same time the annual loss by discharge on certificate of disability was 68

per 1,000 for the regulars and 91 per 1,000 for volunteers. In all foreign armies in which the physical standard required of the recruits is high, as in the German army, the rates for sickness and death are proportionately low.

While military hygiene can do much to preserve the health of the originally sound and robust, in the military service—as in the struggle for existence elsewhere—it is the weak and physically defective which are the first to succumb to hardship and disease. Hence, in the prompt rejection of the unfit, the future cares of the medical officer and the liability to epidemics are proportionately diminished. It should be remembered that the evils resulting from a high sick-rate are not confined to the hospitals, the number and size of which, in an army of theoretically sound men, should be largely determined by probable casualty rather than sickness. The efficiency of the army is impaired not only proportionately to the number of absentees, but is also reduced through the extra expenditure of energy required on the part of the effective force in performing the additional duties which thus devolve upon them. The general efficiency is thus not only weakened, but it is weakened in such a way as to seriously interfere with the process of repair. The places of the dead may be promptly filled with recruits; but those cumbering the hospitals with their chronic disabilities are still borne on their regimental muster rolls and cannot be replaced by more vigorous individuals so long as they are sick and are permitted to remain in the service. The ineffective man therefore weakens the ranks he was intended to strengthen. He serves but to fill the hospitals, load the trains on the march, consume supplies, and require the care of the effective and able-bodied to minister to his infirmities—and this at a time when his own services are wanted in the field. As expressed by Tripler, if the examiner keeps in mind that the strength of an army is determined by the number of rifles in the field rather than the number of names upon the rolls, he will be less desirous of accepting numbers of recruits than that those whom he shall have certified to be free from defect shall not fail in the hour of trial. Particular care is necessary in the examination of men for the volunteer service. The volunteer officers themselves are largely ignorant of the vital importance of rejecting the unfit and desire their regiments to be filled as soon as possible; while patriotic motives inspire applicants for enlistment to conceal their defects from the examining officer. On being assigned to duty with newly raised troops, undergoing organization, the first duty of the sanitary officer is therefore to institute such re-examination of the personnel as will result in the elimination of all those unsuited to the profession of arms by reason of physical disability or mental infirmity.

Defectives.—Weak or poorly developed men spend a large part of their time in hospitals, and in time of war are usually unable to render any service. As expressed by Greenleaf: "There is probably no one class of men which furnishes such large numbers to the hospitals, the guard-house, and the list of deserters as this, designated by military men as 'poor physique,' 'feeble constitution,' or 'general unfitness.'" This opinion is shared by Notter and Firth, they believing also that a close correlation exists between the physical and moral development of men; in fact, lowering the physical means lowering the moral standard of recruits. Where

a service dips too low for its material it will be liable to get men not only small but unsteady, wanting in mental ballast as well as physical strength and resistance to disease. The nerves and muscles are built up by the same process of nutrition, and the weighing machine is probably the best of all means available for testing the general fitness of the recruit.

Nativity.—This, as subsequently shown, exerts a certain influence upon sick-rates and physical development. Contrary to the opinion entertained by the general public, the standing army of the United States contains no large proportion of men of foreign birth. Of 52,077 recruits accepted during the six years 1892–97, a period of peace, 70.69 per cent. were born in the United States. To still further insure that the army should represent the country at large and be in sympathy with republican institutions, Congressional action has recently provided that no applicant should be enlisted unless he was a citizen of the United States or had legally declared his desire for naturalization.

TABLE SHOWING NATIVITY OF 52,077 RECRUITS ACCEPTED FOR SERVICE IN THE UNITED STATES ARMY FOR THE SIX YEARS 1892–97.

	1892.	1893.	1894.	1895.	1896.	1897.	Total.
United States	6,346	5,789	5,040	6,285	6,498	6,850	36,808
England	300	338	237	197	218	214	1,504
Scotland	53	65	58	50	37	49	312
Wales	9	8	13	9	7	4	50
Ireland	897	841	708	652	643	713	4,454
Canada	218	189	129	141	133	122	932
Other British Possessions	8	14	8	12	6	6	54
France	21	22	21	22	14	23	123
Belgium	8	9	5	9	5	7	43
Holland	11	12	13	17	13	9	75
Denmark	96	112	89	78	70	69	514
Norway	67	73	53	46	46	49	334
Sweden	153	139	116	116	101	129	754
Germany	880	812	706	769	645	743	4,555
Switzerland	72	64	45	38	40	63	322
Austria	80	71	84	83	62	65	445
Bohemia	15	22	4	10	14	20	85
Hungary	19	9	8	11	7	10	64
Poland	22	33	9	6	14	12	96
Russia	71	80	47	59	49	41	347
Italy	19	13	15	14	13	10	84
Other countries	23	17	26	19	19	18	122
Total	9,388	8,732	7,434	8,643	8,654	9,226	52,077

Previous Status.—Class and occupation exert a marked and often characteristic influence upon susceptibility to disease, the physical development, and, in the latter case, the conformation of recruits. In our own service, enlistments for the regular army are usually made from the lower walks of life and the laboring classes; but in time of war, and particularly in the volunteer forces, all sorts and conditions of men are attracted to the colors through motives of patriotism and love of adventure. This was especially noteworthy in the case of one of the cavalry regiments organized for service during the war with Spain. No figures affording a means of comparing the physical qualifications of the several social classes have ever been compiled from our military records, but this has been done to some

extent in foreign services. In a recent report of the British War Office the physique of officers and enlisted men is compared, and it is shown that the "better classes" of society are also better physically. Officers, on entering the British army, average two inches taller, are from two to five pounds heavier, and have two or three inches greater chest girth than recruits; and this in spite of the fact that the men average nearly two years older than the officers at enlistment. In the French army a similar comparison is greatly to the advantage of the officers; and it may be accepted that generations of breeding, unconscious selection, and more favorable environment tell on the human animal like any other. As regards the one matter of vision, however, the recruiting officers of the British service have found that imperfect or defective eyesight increases with ascent in the social scale. It is, on the whole, less perfect among the better than the lower class of recruits; and also, naturally, among those drawn from towns than those enlisted in the rural districts. The unequal physical development induced by occupation is so well recognized that no discussion of the subject is here required.

In peace the United States army is recruited largely from the ranks of unskilled labor, with a fair proportion of clerks and mechanics. As a rule, these soldiers are men more of brawn than brain who enlist at first from no particular liking for the military profession but merely as a means of securing a present support—those who develop an aptitude for arms re-enlisting at the expiration of their term of service. The number of men enlisting in any one year from each class is naturally largely dependent upon the industrial conditions affecting their trade or handicraft. In periods of profound business depression an unusually desirable type of men become applicants for enlistment.

OCCUPATION OF 9,585 RECRUITS ACCEPTED IN THE UNITED STATES ARMY IN THE YEAR 1892.

Unskilled laborers	2,270
Soldiers and sailors, re-enlistments	2,130
Agriculture and stock-raising	1,235
Professional and commercial	899
Building trades	592
Workers with horses	496
Mines, metals and machinery	481
Dealers and workers in food products	336
Electricity and transportation	304
Workers in cloth and clothing	155
Unclassified	151
Personal service and attendance	148
Printing trades	121
Workers in leather	117
Makers of furniture and other workers in wood	101
Workers in liquors and tobacco	34
Jewelry	20
Hatters	9
No occupation given	86

In time of war, as above mentioned, the classes from which the volunteer regiments are recruited differ somewhat from those from which the regular forces, in time of peace, are drawn. It is evident, of course, that a regiment raised in a large city will differ considerably from one raised in the country in respect to the previous avocations of the enlisted strength. The 161st Indiana Infantry, recruited during the war with Spain from country districts and small towns in that State, may, however, be accepted as generally typical in its constituency of volunteer forces. This regiment was composed as follows:

Skilled laborers	413
Unskilled laborers	362
Farmers	296
Clerks	118
Students	58
Professional men	47
Merchants	25
Total	1,319

The average age of this regiment was 24 years, the average weight 149 pounds and the average height 5 feet 8 inches. Of the total number, 1,265 men were of American birth while 54 were of foreign nativity—1,191 being single and 128 married.

The military forces of Great Britain, the only European power in which the system of recruitment by voluntary enlistment prevails, are similar in their personnel to our own; laborers, servants, and farmers furnishing about sixty-five per cent. of the whole, artisans about fifteen per cent., and the remainder scattering.

Physically, the regular troops are picked men while the volunteers are liable not to be so well selected in that respect.

As might be expected, also, the city-bred applicants for enlistment are not physically equal to those from the country; but, on the other hand, the consensus of opinion is that men from the rural districts break down more readily under military conditions than do those from cities. As stated by Woodhull, "the agricultural recruit will be better nourished and at first may appear the most vigorous, due to his previous life of moderate exercise in the open air, uninterrupted nightly sleep, and of stated and sufficient meals. His mind and body work slowly and generally best in accustomed grooves. To him the plain and more scanty food, the garrison exercises, or the more fatiguing marches, the prompt obedience without discussion and the sharp movements without voluntary rest, the excitement of active service, the lack of comfortable surroundings when the day's work is over, and especially the exposure at night—marching on guard in all weathers with broken and insufficient rest—all these are conditions that disturb and lower his physical estate until he becomes inured to them. On the other hand, the young man from the city has been accustomed to all grades of physical and mental excitement, he has probably eaten spare, irregular, and poorly cooked meals, and has lived in crowded and ill-ventilated rooms. He may have been insufficiently clothed, and has certainly

been used to late and irregular hours and to spasmodic physical exertion. Both mind and body are more active, and, although the body may appear less stalwart, he represents the survivors in a struggle for existence which has not beset his companions from the country. Discipline is distasteful, but its methods and aims are more readily grasped. To him the military life is physical promotion, in that it substitutes regularity, system, and sufficiency for irregularity and inadequacy in meals, exercise, clothing, hours, and amount of rest and atmospheric purity. The new conditions disturb both classes, but to the city man less inconvenience follows. This is distinctly tested where city and country regiments lie side by side or where a city company has been incorporated in a country regiment. After elimination by length of service the country regiments rival those from the city in endurance, and generally excel them in the familiarity in the ways and with the implements of outdoor life."

Age.—In time of peace age exerts a strong influence upon military morbidity and mortality, and during campaign its effect becomes much more apparent. It should be borne in mind that the real hardships of war happen during the performance of long and harassing marches with the incidental privations which precede actual conflict, and it is under these latter circumstances that the physical difference between the old campaigner and the young soldier becomes most manifest. All military experience is opposed to the enlistment of minors for active service, and lowering the age is well recognized as lowering the effectiveness of an army. In referring to the Indian Mutiny it was said by Gordon that "old regiments marched in the most trying season of the year with comparatively little loss by disease other than by epidemic cholera, while the young soldiers sent to their relief were literally dying by scores." It has long been known that "in campaign the young men succumb while the old soldiers become more hardy and stronger every day." In the Crimea, when notified that recruits were ready, Lord Raglan replied that "those last sent were so young and unformed that they fell victims to disease and were swept away like flies," so he preferred to wait rather than have young lads sent out as soldiers. The Duke of Wellington looked upon old soldiers as the "soul and strength of the army;" and Napoleon, in calling for 300,000 men in 1813, desired that they be "men and not boys, who serve only to encumber the hospitals." As stated by Marshall, "to accept recruits before they have acquired sufficient strength to qualify them to execute their duties and to undergo the fatigues of a military life is to multiply the victims of disease and vexation and to augment the expense of an army without adding to its strength." The French army which gained the day at Austerlitz contained no men below the age of twenty-two years, and marched upward of 400 leagues, leaving but few sick *en route;* on the other hand, the army victorious at Wagram was mainly composed of young soldiers, who are said to have filled the hospitals and marked the roads with their corpses. In the Franco-Prussian war the later French levies suffered the most; and, in time of peace, in 1891, the hospital admissions of French soldiers were 219 per 1,000 for those having more than one year of service, and 316 per 1,000 for those less than twelve months with the colors. Soldiers in the German army in the first two years of service furnish three-quarters of all the cases of typhoid

fever. In 1883, of the British army in India, according to Eyre and Spottiswoode, 41 per cent. was under twenty-five years of age, and among them the death-rate from typhoid fever was 4.34 per 1,000; while among men twenty-five to twenty-nine years of age, forming 35 per cent. of the army, the mortality from this cause was only 1.50 per 1,000. According to Aitken, a large proportion of such soldiers as are discharged for disability from the British service are under twenty years of age. Of our own service it is stated by Rosse that a decade ago the greater proportion of sickness occurred in the younger soldiers; while up to the age of twenty-four the rate proved so much above the mean for the whole army that in 1881 the surgeon-general concluded that "it may fairly be questioned whether the services of these young men are equal to the cost of their maintenance." Laveran observed that during campaign in hot climates the young recruits furnish a disproportionately large share of the sickness and deaths; and Coustan is convinced that soldiers under the age of thirty years should never be sent to tropical countries. Rough states that "young men are more readily fatigued and much more liable to nostalgia, a condition which not only predisposes to sickness but aggravates its effects." Parkes considered the enlistment of boys of sixteen to twenty-one years a cruel waste, so great is the mortality at that age, and says that "although a recruit may be usefully trained at an early age no man under twenty can be regarded as an efficient soldier fit for service." Experience has sufficiently proved the fact that the soldier must have attained a considerable degree of maturity before he is able properly to execute the arduous duties and undergo the privations incident to military life. On this point a lesson may be profitably learned from the Franco-Prussian War, when the German authorities, instead of filling the ranks with the young and untrained lads included in the contingent for the year, preferred to send into active service the married men of thirty-five years and upward. Fallot, quoted by Ewing, states that "conscripts at the age of eighteen have not attained their full growth, and medical men are well aware that the complete development of the human body requires an exemption from great fatigue, abundance of healthy nourishment, undisturbed sleep, and a tranquil mind—a concurrence of circumstances which never occurs in the army."

From the standpoint of developmental anatomy the soldier should certainly not be enlisted before the age of twenty-one years, and a delay of an additional twelve months would be not undesirable. At eighteen years the bones are not fully formed and their actual growth continues until the twenty-fifth year, osseous development preserving a distinct and definite sequence. The epiphyses of the transverse and spinous processes of the vertebræ hardly commence to ossify before sixteen years of age, and it is not until after twenty years that the two thin circular plates form on the bodies of the vertebræ, while the whole process is not completed until the thirtieth year. The sacrum commences to consolidate at the eighteenth year and the process is completed from the twenty-fifth to the thirtieth year. The fourth and third bones of the sternum are united between the twentieth and twenty-fifth years, and the second is not united to the third bone before the thirty-fifth year. The epiphyses of the ribs commence to grow between the fifteenth and twentieth and are not completely joined

to the bone until the twenty-fifth year. The epiphyses of the scapulæ join between the ages of twenty-two and twenty-five; while the epiphysis of the clavicle begins to form between the ages of eighteen and twenty years. The internal condyle of the humerus unites at eighteen, but the upper epiphysis does not join until the twentieth year. The epiphyses of the radius, ulna, femur, tibia, and fibula are all unjoined at eighteen years and are not completely united until the twenty-fifth year. The epiphyses of the pelvic bones (crest of the ilium and tuberosity of ischium) begin to form at puberty and are completed by the twenty-fifth year. The greatest growth of the heart takes place between eighteen and twenty-five years, and even at the latter age has not attained its maximum. When cardiac development is deficient, heart failure is liable to occur under unwonted exercise and in emergencies, and irritable heart, unfitting for military service, is thus favored.

Great importance must also be attached to age in relation to the general physical development of the individual. In height, weight, and chest measure the records kept of students at Amherst College show an increase up to the twenty-sixth year. Aitken states that the white American male grows 1.15 inches between the ages of nineteen and twenty-five. Robert found that in French soldiers, observed during the period between the ages of twenty-one and twenty-five, the average increase in height was 20 mm. (.8 of an inch), while this increase of stature in some instances was as much as 40 or 45 mm. Baxter noted that during the Civil War the native-born white recruits between the ages of thirty and thirty-five had an average greater height of .53 of an inch when compared with the stature of the whole army, ranging from eighteen to forty-five years. Audral found that the maximum lung capacity is not attained until the thirtieth year, and that it diminishes after that time; while Quetelet showed that the adult male does not acquire his greatest strength before twenty-five, his muscular power being stationary for the five years from twenty-five to thirty, and then diminishing.

The results obtained by Quetelet are as follows:

Age.	Lumbar strength. Kilograms.	Strength of both hands. Kilograms.	Age.	Lumbar strength. Kilograms.	Strength of both hands. Kilograms.
16.....	102	63	30.....	154	89
18.....	130	79	40.....	122	87
20.....	138	84	50.....	101	74
25.....	155	88			

Statistics would seem to show that the maximum physical development is found in Americans between the twenty-fifth and thirtieth year; although it is estimated by Gould that the white native of the United States does not attain his full growth until between thirty-one and thirty-four years of age. It may be safely concluded, therefore, that the maximum physical development is not attained before the twenty-fifth year, and that continuance of the present practice of allowing the enlistment of certain recruits as young as the age of eighteen years is, in this country of small military establishment and vast population, as undesirable as it is unnecessary.

Where a minor offers the written consent of parent or guardian, the question then presents itself whether so young a person possesses the vigor and physical development necessary for the performance of all the duties of a soldier. Young men are more easily trained and moulded than are their elders, especially for cavalry, and when well led fight as well as far as mere physical courage goes. Young recruits, however, have not only to work but also to grow and develop, and hence should have precisely the quantity and quality of exercise best fitted for their needs. Under the conditions incident to campaign the staying power of the immature youth is found wanting. His undeveloped body often yields to the strain and a consequent permanent disability leads to his discharge from the army and application for a pension. It is useless to expect any long-continued energy or exertion from the undeveloped and immature, and if such are to be enlisted this fact should be recognized and the work suited to their strength. "If the young man of twenty years has the maximum of suppleness and facility of accommodation to conditions, it is the man of twenty-five or thirty years who possesses the greatest vigor and stamina." The history of the past is full of evidence that too young men are not fit for such duty as soldiers are called upon to perform, and hence their enlistment should be discouraged where it cannot be actually prohibited.

The minimum age under regulations at which the recruit might be enlisted in our service has been practically constant at eighteen years; while the maximum has varied from the peace standard of thirty-five to forty-five in the early part of the century and fifty during the second war with Great Britain. In the Civil War volunteers were accepted between the ages of eighteen and forty-five, but no drafts were made below the age of twenty years. In time of peace nearly all the original enlistments are under thirty years of age; in 1897, of the recruits enlisted, 43.5 per cent. were between the ages of twenty and twenty-five years. According to Baxter, out of 190,621 whites, Union soldiers enrolled during the Civil War, the average age was 26.241 years. At the same time the proportion under twenty-one years of age, according to strength, was:

18 years	159.773	per 1,000
19 "	78.659	" "
20 "	74.210	" "
Total under 21 years	380.479	" "

The following are the minimum requirements as to age, as given by Onslow, for recruits in various European armies:

Great Britain [1]	18 years
France	20 "
Austria [2]	20 "
Germany	20 "
Russia	21 "
Italy [2]	20 "

[1] It is distinctly provided that recruits not arrived at their majority shall satisfy, through their unusual development, the physical requirements provided for men of twenty-one years of age.

[2] The year the recruit becomes twenty.

In this connection the following figures given by Aitken for the British army in India, for the decade 1876–1885, are of interest:

Under	18	years,	per	1,000	strength	7.6
	18–19	"	"	"	"	5.1
	19–20	"	"	"	"	15.6
	20–21	"	"	"	"	50.9
	21–22	"	"	"	"	70.4
	22–23	"	"	"	"	87.8
	23–24	"	"	"	"	94.3
	24–25	"	"	"	"	91.3
Over	25	"	"	"	"	577.1

In foreign services the necessity of maintaining large standing armies has caused a lowering of physical standards which need not be adopted in our own army. With an abundance of material upon which to draw there is no reason for the enlistment of recruits who have not attained their full physical powers. It would conduce greatly to the efficiency of the service if no enlistments were made among men of less than twenty-two years of age.

Although immature men should never be accepted, it would be equally unfortunate to enlist those who are too old, and, with regard to the maximum age for military service, it is probable that after thirty-five years of age the untrained recruit does not possess that flexibility and freedom of motion of the joints and that power of ready co-ordination which is necessary for acquiring the military education. Kirkhoff noted that after forty years the infantry soldier soon becomes unfit for service; and this fact is tacitly recognized in our army in the law which permits the retirement of enlisted men after thirty years with the colors. The legal limit for enlistment of thirty-five years of age is the very extreme for recruits under ordinary circumstances, and the nearer common laborers approach that age the more unlikely are they to be acceptable. It has been observed that for desirable colored recruits the age of twenty-five or twenty-six is practically the maximum, since after that time they are liable to be physically stiffened and mentally dulled.

For the determination of age in the recruit, as stated by Greenleaf, "certain well-known and clearly marked physical characteristics will enable the recruiting officer to decide at a glance whether or not an applicant for enlistment shall be placed in the broad mean as to age between the minimum and maximum fixed by law, although to determine in an individual either the age of majority—*i.e.*, twenty-one years—or the maximum age for enlistment, is always difficult and often impossible. The desire to enter the military service is sometimes, from varying causes, so strong as to prompt certain youths or middle-aged men to resort to any deceit for the purpose of concealing the truth. Boys will announce themselves as of age with unblushing effrontery, and men who are over the maximum will add to falsehood the most ingenious artifices to disguise the evidences of advancing age. The development of the body does not necessarily keep pace with its years of existence. Youths of eighteen or nineteen years occasionally present many physical characteristics of maturity,

while some men pass the age of thirty-five without showing well-marked indications of it. Little importance need be attached to this latter phase, because the maximum limit does not apply to soldiers who re-enlist, and during peace but few civilians present themselves after that age. The former condition is, however, an important one and demands close attention. The evidences of maturity which usually accompany the period of legal majority are as follows: At twenty-one years of age the wisdom teeth are usually cut, and on each side of both jaws there should be found five grinders, viz., three large double or molar teeth and two smaller double or bicuspid teeth. Under twenty-one years of age the wisdom teeth are seldom to be found. At maturity there should be some beard upon the face, and hair under the arms, a full growth around and above the genital organs, and some scattered hairs in the neighborhood of the anus. The hair of the body is generally fine and silky; while after maturity it is thick and coarse in the various places mentioned. After maturity the skin of the scrotum is somewhat darker in color than the surrounding parts, is opaque, and is marked in various directions by wrinkles or folds. Before this period such skin retains the soft, velvety condition of youth, its pink or flesh color, and is more or less translucent, while the wrinkles or folds are not well pronounced, or are entirely absent, particularly at the sides. This condition of the scrotum is the most valuable of the signs of maturity."

Height.—That stature is largely a question of race has long been demonstrated; yet within racial lines it is a matter of class and, among classes, of age, occupation, diet, and environment. According to Kilbourne, the following is the average height of the various classes from which the material for our army must be chiefly recruited:

	Feet.	Inches.
North American Indians	5	7.93
United States whites (Union soldiers in Civil War)	5	7.67
Norwegians	5	7.66
Scotch, United States immigrants	5	7.06
Canadians	5	7.01
Swedes, United States immigrants	5	6.90
Irish, United States immigrants	5	6.74
Welsh	5	6.66
American negroes	5	6.62
English, United States immigrants	5	6.58
Hungarians, United States immigrants	5	6.58
Germans, United States immigrants	5	6.54
Swiss, United States immigrants	5	6.38
French, United States immigrants	5	6.27
Poles, United States immigrants	5	6.20
Italians, United States immigrants	5	6.00
Austrians, United States immigrants	5	5.58

From the above table it is evident that in our service, the recruits for which are drawn from all classes of foreign immigrant stock, the observance of rules establishing a fixed minimum is less desirable than in a country possessing a more physically homogeneous population. Deficient stature, when estimated according to the standard for each race, implies a lack of osseous growth which, in a large majority of cases, is accompanied by proportionately defective muscular development and power, together with lowered vital resistance. Mean height for different races,

however, is comparative and not absolute, and the height of sixty-two or sixty-three inches indicates degeneracy in the native American where the Latin of the same stature is not far removed in this respect from his racial normal. While with peace conditions an abundance of recruits can be obtained under existing restrictions as to height—excellent when applied to native-born recruits—there should be some provision by which, for war service, the rejection of the comparatively undersized but muscular Slav and Latin, both notoriously hardy in campaign and in the performance of heavy manual labor, should not be obligatory upon the recruiting officer.

While height has been accepted by some as being a physiological expression of constitutional force, the vital resistance and endurance of the individual, as well as the maximum strength, is based rather upon the symmetrical development of all parts of the body. Beyer, however, considers that increase in height is a factor of the greatest importance in determining the ultimate degree of development in young men under physical training, in which instance he considers that increased height means also increased strength; but the strongest individuals are not usually of great stature, and excessive height rarely implies a corresponding increase of general physical development and muscular power. Many centuries ago Vegetius wrote that "it is of much more importance that the soldier should be strong than that he should be tall," and in the military service of the present day an even less necessity exists for men above the mean in size. The average stature of a youth of eighteen years of age, a "growing lad," is a little over 5 feet 4 inches, and this increases gradually until he reaches the age of twenty-five years—about the stage of physical maturity or manhood—when his average height is between 5 feet 7 inches and 5 feet 8 inches. During the growing period the framework and vital organs receive their proper development, and considerable departures from the given average of proportionate height to weight indicate an impairment of these organs which may and probably will develop into positive disease after exposure to the hardships incident to the life of a soldier; hence they are of greater significance in men of these heights than in taller men, who are presumably of greater age and more mature growth. During the Civil War the average height, age and chest girth of 190,621 native white Americans, examined and accepted for the military service of the United States, was found by Baxter to be as follows:

Height.	Number.
Under 61 inches	609
61 to 63 "	4,929
63 to 65 "	21,712
65 to 67 "	47,731
67 to 69 "	58,348
69 to 71 "	38,935
71 to 73 "	14,858
73 and over	3,499

Mean age	26.96 years.
Mean chest girth	35.25 inches.
Mean height	67.35 "

The minimum limit of stature for the recruit has varied greatly in our service. Shortly after the Revolution it was fixed at 5 feet 6 inches, and in 1835 a minimum of 5 feet 8 inches for infantry was required. In 1838 it was reduced to 5 feet, but this was increased by 5 inches three years later. Before the end of the Civil War it was again reduced to 5 feet. At present it is placed at 5 feet 4 inches for all branches of the

service, although recruiting officers are allowed to exercise their discretion as to the enlistment of desirable recruits (such as band musicians, school-teachers, tailors, etc.) who may fall not more than a fraction of an inch below the minimum standard of height. The above requirement for height is, however, subject to change, instructions to that effect being issued from the adjutant-general's office "from time to time as the requirements of the service may dictate." In foreign armies the minimum height of the soldier is at present fixed as follows:

	Meters.		Meters.
English	1.62 (64 inches).	Swiss	1.55
Swedish	1.60	French	1.54
German	1.57	Russian	1.53
Belgian	1.57	Spanish	1.50
Italian	1.56	Portuguese	1.50 (59 inches).
Austrian	1.56		

It is a demonstrated fact that very tall men cannot for long support the fatigues of arduous military service; and excess of height, in the absence of proper and proportionate general physical development, is cause for rejection the same as a deficiency in stature. In men of great height the chief development is usually in the lower limbs, and in young and very tall recruits the excess of their growth becomes obvious by contrast with the narrow flat chest, in which the apices of the lungs closely approach each other. Aitken noticed that the majority of cases of tuberculosis in soldiers were found in tall men, and believed that the taller the recruit the more his lungs should be tested with the spirometer—while Baxter found that during the Civil War the ratio of rejections increased with increase of height. According to Viry, the French grenadiers are notoriously inferior as marchers to the voltigeurs or infantry of the line. Men of large size require proportionately more food than do those of smaller stature, besides presenting larger surface to the bullets of the enemy. It is obviously an advantage to exclude men of great height from the mounted service and thus avoid the carriage of an unnecessary weight by the horses. For all arms of the service the enlistment of stocky, muscular men of medium height is most desirable. In our cavalry and light artillery establishment the maximum height is 5 feet 10 inches; that for infantry and heavy artillery being governed by the maximum of weight, to which should be applied the rule for the proportion of height.

Weight.—Weight, to be effective, should be chiefly in bone and muscle, since fat, more than is necessary for filling in and rounding out the figure, is dead weight and diminishes capacity to perform work. Weight varies directly with age and height and, according to Aitken, good weight for height is of even more importance than an ample chest measure. As a result of his investigations, Quetelet obtained the following figures:

Age.	Height. Meters.	Body Weight. Kilograms.	Age.	Height. Meters.	Body Weight. Kilograms.
17	1.634	52.85	25	1.680	62.96
18	1.658	57.85	30	1.684	63.65
20	1.674	60.06	40	1.684	64.67

The most important point to consider in regard to weight is the minimum compatible with military efficiency. Parkes placed the weight of 115 pounds as the minimum for the recruit of eighteen years of age, but at the same time advised against the enlistment of such a class of men; while, according to Fetzer, it is rare to find among men having a height of 1.57 meters those who, weighing less than 60 kgm. (132 pounds), would make good soldiers. Vallin believed that men of a height of 1.70 meters should weigh not less than 60 kgm. and those of 1.80 meters not less than 70 kgm. Morache concluded that the weight, based upon the height, should be as follows:

Meters.	Kgm.	Meters.	Kgm.
1.55	56	1.65	61–62
1.60	58–60	1.78	63–64

The minimum weight for all recruits in our service is 125 pounds, except for cavalry, in which arm enlistment may be made without regard to a minimum standard, provided the chest measurement and chest mobility are satisfactory. Foreign standards place the average increase of weight with the height at about 0.75 kgm. for each centimeter of stature. The rule in use in our own service considers that up to 5 feet 7 inches twice the height in inches should represent the weight in pounds, adding 7 pounds for each inch above 5 feet 7 inches. This standard of weight may, with experienced examiners, be advantageously varied; since many young men of excellent bone may be temporarily under weight through defective nourishment, hard labor, or sojourn in hot climates, but be none the less vigorous and physically adapted to military service. The weakness of such men is apparent rather than actual.

After twenty-five years of age, the body being fully developed, the excess of nutritive material over and above that required for its maintenance in health is deposited in the tissues as fat, and it will be found that a disproportion of weight over height occurs usually in adults or men in middle life. It is rare to meet in the recruiting rendezvous with very fleshy young men. Huxley regards the proper weight of man as 154 pounds. This, however, is much in excess of the mean for our military service, which, for men of twenty to thirty years, is about 145 pounds.

It is better that recruits, if muscular, be over than under weight. Marked disproportion of weight over height does not disqualify for the military service, but positively obese men should be rejected. All things considered, the maximum United States army weight of 190 pounds for foot service is well placed, since the overweight man is handicapped by his superfluous flesh; but it is well to remember that a sedentary occupation may favor a temporary inclination toward obesity which yields promptly to military conditions. In this connection the history of the recruit should be given some consideration, particularly in time of war, when men are urgently needed, and cases should not be judged too hastily on the basis of overweight alone. For cavalry and light artillery the maximum weight is wisely established at 165 pounds.

Chest Measure.—The thorax, containing the heart and lungs, is the most important division of the body. It contains the vital machinery and

represents the staying power of the man. It must, therefore, be ample. The function of the legs is to transport the body; they should be well formed and sufficient, but not unduly long—for length of limb at the expense of the chest is a disadvantage. A long-legged, long-necked man with a short chest is objectionable as a recruit. The size of the chest is an excellent indication of the vital resistance of the individual. It should be large, well formed, and inclined to rotundity rather than flatness. As to chest measure, Leeland and Stolaroff concluded from their researches that in the properly proportioned individual this should exceed the half height by from 25 to 40 mm. Seggel, as the result of a large number of measurements, arrived at the opinion that if the width of the shoulders and the diameter of the chest should together equal or exceed the demi-height the recruit might be considered as acceptable. He believed that the width of the shoulders in connection with the chest measure should be recognized as an important factor in the selection of the soldier, placing this width, in the properly built man, at two-ninths of the height. Fetzer considered that a chest measure of 0.76 meter (30 inches) indicated the lowest limit of physical aptitude for military service; but this standard, based on the necessity for a large number of men and on the comparatively undersized population of southern and eastern Europe, is much too low for the native-born American recruit. Bernard showed that the frequence of respiratory and circulatory disease was in inverse ratio to the chest measurements; while Mackiewicz, from the weight and measurement of seven hundred and seventy-one men invalided from consumption, demonstrated that among weak men, as determined by weight and chest measure, tuberculosis occurred four times as often as among sound men. These results are borne out by common experience.

According to Onslow, the minimum chest measurement for the recruit in various European armies is as follows:

England	33 inches.	Russia	No limit.
France	30.86 "	Germany	No limit.[1]
Austria	30.06 "	Italy	31.5 inches.

In Switzerland the chest measure of the recruit is required to exceed half the height. In our service the rule is that "a man whose chest measures less than thirty-two inches in circumference at expiration should be rejected, unless he be considered specially desirable, when the case may be reported to higher authority."

The quantity of air introduced into the lungs at each inspiration is certainly one of the most important elements determining the vital force and physical fitness of the recruit; and the mobility of the chest is in this respect one of the data most necessary to consider, especially with reference to its relation with height and weight. Chest mobility does not necessarily mean chest capacity, however; but where mobility is good capacity is usually satisfactory. Hutchinson states that the breathing capacity normally increases eight cubic inches for each inch of height between five and six feet. The vital capacity attains its maximum at thirty-five years of age, there being an average annual decrease of 1.21 cubic inches from that

[1] But the mobility and conformation are considered in connection with the general physique.

point backward to fifteen and forward to sixty-three years of age. In general, the respiratory processes bear a close relation to the standard of nutrition of the organism. From a large number of observations in the British service the maximum chest expansion of a man of average size, eighteen to twenty-five years, was found to be two to two and one-half inches; rarely three inches. In our army "the chest mobility, *i.e.*, the difference between the measurement at inspiration and expiration, should be at least two inches in men below five feet seven inches in height, and two and one-half inches in those above that height. It is not necessary that the applicant should conform exactly to the figures indicated in the rules, a variation of a fraction of an inch in chest measure being permissible if the applicant is otherwise in good health and desirable as a recruit." Of 9,901 men examined in Illinois for volunteer service during the war with Spain, the chest expansion was found unexpectedly high. The average in their case was 3.67 inches—where Baxter found that during the Civil War 315,620 native-born whites had an average expansion of but 2.807 inches. Among the volunteers above mentioned 4,067 men had a chest expansion of over four inches, and 801 of five inches or over.

In examining the recruit the circumference of the chest is measured by passing the tape around it immediately at the point of the shoulder blade, the arm hanging down. Generally the tape will then be found to fall below the nipple. In taking this measure contortions of the body should be avoided. For the determination of the vital capacity the spirometer naturally gives more exact results than does the tape, but resort to this apparatus is unnecessary in practice.

In the field, ill-adjusted packs tend materially to derange the chest organs. Even the canteen and haversack straps may press on the immature recruit to his lasting detriment, and, next to the inspiration of bad air, the imperfect or continuously obstructed expansion of the chest tends more than any other cause to bring about disease of the heart and lungs. In this respect, during campaign, the unformed chest of the recruit suffers much more severely than that of the seasoned soldier, and it is never advisable to accept the physically defective with the idea that the thorax will be developed by a military life. As a general rule, large men are proportionately less developed as to chest than smaller men, but the influence of height on capacity of respiration is much greater than is that of weight. In obese individuals the chest mobility is never great.

Average Proportions.—It should be understood that age, weight, height, and chest measure are very closely correlated in the growth of the healthy human being to the full development of his strength and powers of endurance, and that the maintenance of due proportions in these factors is absolutely necessary in order to enable the soldier to sustain the fatigue and hardships incident to the profession of arms. All the conditions of military life are established on the basis of uniformity; and as far as possible average conditions of the above factors are required to co-exist. The march step is designed for men of mean height, not the very tall or short, while the weight of the equipment is proportioned to the average strength of the bearer. Hence the individuals above and below the normal line are at a physical disadvantage. All experience goes to show that the men most suitable for the military establishment are the typical men whose

Age.	Whole Number Accepted.					Average Height (in Inches).					Average Weight (in Pounds)					Average Chest Measure (in Inches).									
	White.			Colored.	Total white and colored.	White.			Colored.	Total white and colored.	White.			Colored.	Total white and colored.	White.						Colored.		Total white and colored.	
	Native.	Foreign born.	Total.			Native.	Foreign born.	Total.			Native.	Foreign born.	Total.			Native.		Foreign born.		Total.					
																Expiration.	Inspiration.	Expiration.	Inspiration.	Expiration.	Inspiration.	Expiration.	Inspiration.	Expiration.	Inspiration.
16	8	....	8	1	9	66.53	....	66.53	63.25	66.17	122.75	....	122.75	125.00	123.00	30.56	33.44	....	....	30.56	33.44	31.75	34.00	30.69	33.50
17	19	....	19	1	20	66.64	....	66.64	64.75	66.55	128.32	....	128.32	137.00	128.75	31.70	34.58	....	....	31.70	34.58	32.00	34.50	31.71	34.58
18	1	....	1	..	1	64.00	....	64.00	....	64.00	125.00	....	125.00	....	125.00	32.00	34.50	....	....	32.00	34.50	....	....	32.00	34.50
19	8	....	8	..	8	68.25	....	68.25	....	68.25	141.25	....	141.25	....	141.25	32.03	35.31	....	....	32.03	35.31	....	....	32.03	35.31
Under 20 (average, 17.2)	36	....	36	2	38	66.90	....	66.90	64.00	66.75	129.86	....	129.86	131.00	129.92	31.53	34.49	....	....	31.53	34.49	31.88	34.25	31.55	34.48
20	7	....	7	..	7	68.79	....	68.79	....	68.79	143.71	....	143.71	....	143.71	32.43	35.43	....	....	32.43	35.43	....	....	32.43	35.43
21	1,556	167	1,723	99	1,822	67.75	67.04	67.68	67.34	67.66	143.05	141.60	142.91	146.26	143.04	33.82	36.80	33.96	36.82	33.83	36.80	33.72	36.50	33.83	36.79
22	642	112	754	53	807	67.66	67.13	67.59	67.26	67.56	144.33	143.82	144.25	146.75	144.42	34.05	37.07	34.25	37.29	34.08	37.11	33.64	36.36	34.05	37.06
23	516	81	597	40	637	67.90	67.54	67.85	67.30	67.82	145.48	144.30	145.32	148.08	145.49	34.19	37.19	34.35	37.33	34.21	37.21	33.90	36.95	34.19	37.19
24	522	167	689	59	748	67.94	67.37	67.80	67.54	67.78	146.86	146.80	146.85	149.32	147.04	34.22	37.27	34.61	37.69	34.31	37.39	33.90	36.56	34.28	37.31
20 to 24 (average, 22.1)	3,243	527	3,770	251	4,021	67.79	67.24	67.71	67.37	67.69	144.30	144.14	144.28	146.98	144.45	33.92	36.99	34.29	37.27	34.04	37.03	33.77	36.56	34.01	37.00
25	434	156	590	53	643	67.69	67.12	67.54	67.80	67.56	145.50	146.38	145.73	147.87	145.19	34.22	37.26	34.66	37.71	34.33	37.39	34.01	36.66	34.31	37.32
26	431	164	595	63	658	67.93	67.26	67.74	67.79	67.75	148.30	146.24	147.73	148.92	147.85	34.34	37.40	34.58	37.55	34.40	37.43	34.14	36.91	34.38	37.39
27	319	157	476	58	534	67.95	67.49	67.80	67.35	67.75	147.55	148.31	147.80	150.43	148.09	34.46	37.42	34.86	37.94	34.59	37.59	34.24	37.05	34.55	37.53
28	262	110	372	37	409	67.50	67.98	67.63	67.91	67.67	147.52	145.73	146.99	151.64	147.40	34.52	37.57	34.83	37.80	34.61	37.64	34.56	37.42	34.60	37.62
29	209	93	302	35	337	67.77	67.20	67.60	67.94	67.63	149.10	149.63	149.26	151.71	149.52	34.51	37.60	34.77	37.88	34.59	37.68	34.33	37.07	34.57	37.62
25 to 29 (average, 26.7)	1,655	680	2,335	246	2,581	67.78	67.39	67.67	67.73	67.67	147.40	147.13	147.32	149.85	147.56	34.32	37.42	34.73	37.76	34.48	37.52	34.22	36.99	34.46	37.51
30	134	108	242	21	263	67.68	67.31	67.52	67.45	67.51	150.09	147.28	148.83	149.62	148.90	34.60	37.65	34.84	37.88	34.71	37.75	34.24	36.81	34.67	37.67
31	129	115	244	37	281	67.59	67.40	67.50	67.70	67.53	147.77	150.79	149.19	155.81	150.06	34.50	37.48	35.00	38.12	34.74	37.79	34.97	37.47	34.77	37.74
32	94	92	186	31	217	67.79	66.99	67.39	67.81	67.45	150.83	146.00	148.44	160.13	150.11	34.69	37.80	34.83	37.72	34.76	37.76	35.31	37.97	34.84	37.97
33	68	80	148	8	156	67.60	67.12	67.34	67.50	67.35	148.59	148.06	148.30	151.25	148.46	34.46	37.47	34.69	37.83	34.59	37.67	34.69	37.19	34.60	37.64
34	82	84	166	15	181	67.71	66.93	67.31	67.67	67.34	154.12	146.88	150.10	153.27	150.36	35.09	38.03	34.82	37.82	34.96	37.92	34.67	37.07	34.93	37.85
30 to 34 (average, 31.7)	507	479	986	112	1,098	67.67	67.17	67.43	67.67	67.45	150.09	147.81	148.98	155.18	149.61	34.65	37.67	34.85	37.89	34.75	37.78	34.87	37.41	34.76	37.74
35	78	68	146	18	164	67.98	67.34	67.68	67.35	67.64	156.97	152.59	154.93	151.22	154.52	35.20	38.20	35.46	38.45	35.32	38.31	34.33	37.03	35.20	38.17
36	52	71	123	22	145	67.48	67.07	67.25	67.34	67.26	151.13	148.80	149.79	146.00	149.21	34.74	37.90	34.88	37.80	34.82	37.84	34.43	37.00	34.81	37.71
37	71	86	157	22	179	67.51	66.96	67.21	67.32	67.22	151.51	147.10	149.08	144.50	148.52	34.77	37.69	34.93	37 96	34.86	37.84	34.50	37.38	34.82	37.80
38	67	59	126	16	142	67.98	67.37	67.70	67.00	67.62	155.61	149.49	152.75	161.50	153.73	35.29	38.13	36.15	38.94	35.71	38.50	35.13	37.91	35.64	38.44
39	37	52	89	16	105	67.73	67.58	67.64	68.11	67.71	150.57	148.87	149.57	156.56	150.64	35.00	37.99	34.79	37.70	34.88	37.82	34.89	37.72	34.88	37.81
35 to 39 (average, 36.8)	305	336	641	94	735	67.75	67.23	67.48	67.41	67.47	153.64	149.26	151.34	151.09	151.31	35.02	37.92	35.21	38.16	35.13	38.08	34.63	37.37	35.06	37.99
40 to 49 (average, 43.8)	267	278	545	71	616	67.42	66.81	67.11	67.75	67.18	153.27	151.79	152.52	154.13	152.70	35.33	38.19	35.48	38.06	35.41	38.26	34.82	37.59	35.34	38.18
50 and over (average, 52.5)	49	71	120	17	137	66.92	66.63	66.75	67.76	66.88	151.25	150.49	150.80	154.47	151.26	34.85	37.41	35.54	38.25	35.22	37.90	35.07	37.54	35.12	37.86
16 and over (average, 27.6)	6,062	2,371	8,433	793	9,226	67.75	67.20	67.59	67.56	67.59	146.47	147.55	146.77	150.28	147.07	34.25	37.26	34.84	37.81	34.42	37.53	34.28	37.01	34.42	37.38

physical proportions vary the least from the common mean and who are naturally found in the great majority.

The table on the preceding page shows the average height, weight, and chest measure of 9,226 recruits accepted for the United States military service in 1897; there being 6,062 native whites, 2,371 foreign-born whites, and 793 colored.

The following standards for the United States service are based upon results obtained by skilled observers who, after careful study and the examination of large numbers of men in civil and military life, have established the fact that there is an average proportion in healthy, fully developed men between the height, weight, chest measurement, and chest mobility, which, however, will admit of slight variations without indicating a departure from health.

Height.		Weight.	Chest Measurement.	
Feet.	Inches.	Pounds.	At expiration. Inches.	Mobility. Inches.
$5\frac{4}{12}$	64	128	32	2
$5\frac{5}{12}$	65	130	32	2
$5\frac{6}{12}$	66	132	$32\frac{1}{2}$	2
$5\frac{7}{12}$	67	134	33	2
$5\frac{8}{12}$	68	141	$33\frac{1}{4}$	$2\frac{1}{2}$
$5\frac{9}{12}$	69	148	$33\frac{1}{2}$	$2\frac{1}{2}$
$5\frac{10}{12}$	70	155	34	$2\frac{1}{2}$
$5\frac{11}{12}$	71	162	$34\frac{1}{4}$	$2\frac{1}{2}$
6	72	169	$34\frac{3}{4}$	3
$6\frac{1}{12}$	73	176	$35\frac{1}{4}$	3

In the British service, in 1886, of the men serving with the colors, 901 per 1,000 had a height of five feet five inches and upward; 931 per 1,000 had a chest measure of thirty-four inches and upward, and 834 per 1,000 were over twenty years of age. Similar data with regard to the total enlisted strength of our own service are not available, but as compared with our raw recruits the trained British soldier possesses a slight superiority in chest measure, but is inferior in both age and height.

The Examination of the Recruit.—The profession of arms is arduous, and ample experience has shown the folly of attempting to conduct military operations unless such men as are affected with disease, predisposed to its occurrence, or are unfitted to sustain fatigue and exposure are excluded and eliminated from the service. An effective or healthy military force cannot be made from imperfect or immature men; nor is it true that every man who supports himself by hard manual labor will make an efficient soldier, since all his senses may not be keen, his joints not flexible and he may not be sound.

For determining the physical aptitude for military service many factors must be taken into consideration; the requirements for recruitment necessarily varying with the social conditions of the different countries, as well as with the need for men. Some allowance may be made for blemishes, not affecting organic soundness, which have originated in the service in men who technically re-enlist, since their education in military matters and habits of discipline compensate for some minor weaknesses. In the foreign services, where conscription prevails, the lesser disabilities do not

as readily disqualify as with us, and a man unfit for one branch of the service is assigned to another.

The leading characteristics of a good constitution are thus enumerated by Tripler: "A tolerably just proportion between the different parts of the trunk and members; a well-shaped head, thick hair, a countenance expressive of health, with a lively eye, skin not too white, lips red, teeth white and in good condition, voice strong, skin firm, chest well formed, belly lank, parts of generation well developed, limbs muscular, feet arched and of a moderate length, hands large. The gait should be sprightly and springy, speech prompt and clear, and manner cheerful. All lank, slight, puny men, with contracted figures, whose development is, as it were, arrested, should be set aside. The reverse of the characteristics of a good constitution will indicate infirm health or a weakly habit of body." In general, a weak constitution will be better recognized than described, by the softness of tissue, slightness of form, insufficient development of the skeleton and muscles, and want of harmony between different parts of the body. "The examiner should endeavor to judge from the eyes, from the whole expression of the countenance, from the conformation of the limbs of those who are capable of making the best soldiers; there are as certain and as well understood indications for judging of the soldierly value of men as there are for ascertaining the qualities of a horse or a hunting-dog."

The room in which the examination is conducted should be well lighted and large enough for the men to exercise in walking, running, and jumping, as every organ directly concerned in locomotion should be subjected to inspection. Only those persons whose services are absolutely required should be present at the examination. The body of the recruit should be washed with soap and water before he is presented for inspection. "It is not believed to be good policy to enlist men who, though able-bodied and intelligent, appear at recruiting rendezvous in ragged or filthy dress, as the chances are such men are tramps and vagabonds and will not make good soldiers. Men who, though attired in clean and respectable clothing, are found to be filthy in their persons should be promptly rejected for like reason."

In the examination of the recruit he should, as advised by Greenleaf, take the position of the soldier in the best lighted part of the room, and be examined in the following order:

1. The general physique, skin, scalp and cranium, ears, eyes, nose, mouth, face, neck, and chest should be examined and the chest measurements taken.

2. The arms should be extended above the head, the backs of the hands being together, and the applicant required to cough vigorously; any form of rupture is now readily discovered by the hand and eye.

3. The hands remaining extended above the head, the man is required to take a long step forward with the right foot and bend the right knee; the genital organs are conveniently exposed and varicocele or other defects in the scrotum may be recognized.

4. The arms are dropped and the man required to separate the buttocks with his hands, at the same time bending forward; this exposes the anus.

5. The heart and lungs are examined.

6. The elbows should be brought firmly to the sides of the body and the forearms extended to the front, palms of the hands uppermost; extend and flex each finger separately; bring the points of the thumbs to the base of the little fingers; close the hands, with the thumb covering the fingers; extend and flex the hands on the wrists; rotate the hands so that the finger-nails will first be up and then down; move the hand from side to side; extend the arms and forearms fully to the front and rotate them at the shoulder; flex the forearms on the arms sharply, striking the shoulders with the fists; extend the arms at right angles with the body, place the thumbs on the points of the shoulders, raise and lower the arms, bring them sharply to the side at each motion; let the arms hang loosely at the side; swing the right arm in a circle rapidly from the shoulder, first to the front and then to the rear; swing the left arm in the same manner; extend the arms fully to the front, keeping the palms of the hands together and thumbs up; carry the arms quickly back as far as possible, keeping the thumbs up, and at the same time raise the body on the toes; extend the arms above the head, locking the thumbs, and bend over to touch the ground with the hands, keeping the knees straight.

7. Extend one leg, lifting the heel from the floor, and move all the toes freely; then move the foot up and down and from side to side, bending the ankle-joint, the knee being kept rigid; bend the knee freely; kick forcibly backward and forward and then throw the leg out to the sides as far as possible, keeping the body squarely to the front; repeat these motions with the other foot and leg; strike the breast first with one knee and then with the other; stand upon the toes of both feet; squat sharply several times; kneel upon both knees at the same time (if the man comes down on one knee after the other there is reason to suspect infirmity). Take the position to "fire kneeling"; present the back to the examiner and then hold up to view the sole of each foot; leap directly up, striking the buttocks with the heels; hop the length of the room on the ball of first one foot and then another; make a standing jump as far as possible and repeat it several times; run the length of the room in double time several times.

8. The heart and lungs are re-examined.

9. The hearing of each ear is separately determined.

10. The vision of each eye is separately determined.

11. The test for color-blindness is made.

The duties of the examining officer will be materially facilitated if his clerk or assistant be instructed in the positions of the examination, as the recruit will usually find no difficulty in imitating the necessary movements.

THE GENERAL QUALIFICATIONS OF THE RECRUIT.

The Manual for the Medical Department requires that "in passing a recruit the examining officer is to examine him stripped; to see that he has the free use of his limbs; that his chest is ample; that his hearing, vision, and speech are perfect; that he has no tumors or ulcerated or extensively cicatrized legs; no rupture or chronic cutaneous affection; that he has not received any contusion or wound of the head that may impair his faculties; that he is not a drunkard; is not subject to convulsions, and has no

infectious or other disorder that may unfit him for military service"; also that the recruit must be effective, able-bodied, sober, free from disease, and of good character and habits.

The causes for rejection for service in the army of the United States, having relation to the efficiency of the soldier and his susceptibility to disease, have been well summarized by Greenleaf, whose admirable manual on the examination of the recruit, officially prescribed for the guidance of the examining officer, has been largely drawn upon in the preparation of this section. These defects, surgical as well as medical, may be enumerated as follows, a brief explanation being given to such abnormalities as are not self-evident disqualifications for military service even to the inexperienced examiner:

Mental Infirmities.—Insanity; Idiocy; Imbecility; Dementia.

Moral Infirmities.—Intemperance in the Use of Stimulants or Narcotics; Conviction of Felony; Masturbation; Sodomy.—The moral character should be scrutinized with care in order that enlistments from the vagrant and criminal classes may be avoided. The recruiting rendezvous is a favorite haunt for these men and a study of their personal characteristics will well repay the recruiting officer for his labor.

"The enlistment of . . . intoxicated persons . . . is forbidden." This regulation is intended not only to prevent the admission to the service of men who at the time of enlistment are under the influence of stimulants or narcotics, but of those who are of intemperate habits. Long indulgence in habits of intemperance will almost surely be indicated by persistent redness of the eyes, tremulousness of the hands, attenuation of the muscles—particularly of the lower extremities—sluggishness of the intellect, an eruption upon the face, and purple blotches upon the legs. Close and skilful questioning will often develop the facts connected with the antecedents of the applicant and materially assist the examiner in forming his opinion of the case. Even in time of war there should be no deviation from the rule that those who appear of undesirable character or personality, even if physically acceptable, should be promptly rejected. An army is always better without than with them.

Cerebro-Spinal System.—Epilepsy; Chorea; All Forms of Paralysis; Tabes Dorsalis; Neuralgia; Stuttering.

SPECIAL DISQUALIFICATIONS.

Feebleness of Constitution (Poor Physique); Scrofulous Diathesis; Cancerous Diathesis; Syphilis.—The last disease, recognized by its characteristic symptoms, is at all times cause for rejection. It will be most convenient, while making the general examination of the surface of the body, to search for evidence of a syphilitic nature. In the detection of this no single sign will suffice, although the presence of two or more should determine the matter, especially if the man admits having had a sore on any part of his penis or a chancre on any other part of his body. The rejection of men of poor physique, even if there be no definite lesion or abnormality, is of the greatest importance. Such men are the first to succumb to hardship and to contract disease, while their lack of vital resistance renders their case mortality unduly high.

The Skin.—ALL CHRONIC, CONTAGIOUS, AND PARASITIC DISEASES OF THE SKIN; NÆVI; EXTENSIVE, DEEP, AND ADHERENT CICATRICES; CHRONIC ULCERS; VERMIN.—While skin disease of intractable nature is cause for rejection under usual conditions, in time of war exemption should be given only on account of long-standing or incurable diseases of the skin; the milder forms may be treated with reasonable prospect of recovery in a short time, and the men should accordingly be held to service. A contagious skin disease should be cause for disqualification at any time. Vermin indicate habits of uncleanliness which cannot be tolerated in the military service.

Men whose constitutions have been broken down by poverty or vice are often the subjects of ulcerations of the legs, where the slight injuries to which so exposed a part is liable have failed to heal; or if healed present large irregularly shaped scars, more or less discolored or adherent to the bone. These scars, being unhealthy, are liable upon slight irritation to be destroyed and the ulcer reproduced. Such men are unfitted for soldiers and should be rejected. Scars non-adherent, white and smooth, or even red, when recent, if apparently painless on manipulation, resulting from an incised or lacerated wound or a burn, not involving lesion of the subjacent organs, are not causes for rejection. In time of war conscripts may, with a design of evading service, purposely induce and keep open ulcers. Suspicion will naturally be aroused where a man, otherwise healthy, claims exemption from service on account of an ulcer of long standing; as this lesion is seldom seen except in persons of broken-down constitution and generally in middle or advanced age. The appearance of the ulcer and the tissues surrounding it will furnish some evidence as to its age, active inflammation pointing to voluntary irritation and a recent lesion, while an old ulcer presents reverse characteristics.

The Head.—ABNORMALLY LARGE HEAD; CONSIDERABLE DEFORMITIES, THE CONSEQUENCE OF FRACTURES; SERIOUS LESIONS OF THE SKULL, THE CONSEQUENCE OF COMPLICATED WOUNDS OR THE OPERATION OF TREPHINING; CARIES AND EXFOLIATION OF THE BONE; INJURIES OF CRANIAL NERVES; TINEA CAPITIS; ALOPECIA.—The scalp should be examined very carefully, by running the fingers through the hair, for depressions in the skull. If any are found that are deep and abrupt in character, especially if covered by a scar, the applicant should be rejected—the same applies to deformity of skull resulting from fracture. If the loss of hair is total, or if but a few tufts remain about the back of the head and the neighborhood of the ears, or if the scalp shows evidence of pre-existing disease, the applicant should be rejected. Considerable loss of the hair, either over the crown or above the forehead, is cause for rejection. The military head coverings are not of themselves sufficient protection against heat or cold; there should be enough natural covering in the hairy scalp to provide against suffering or disease from extremes of temperature.

The Spine.—CARIES; SPINA BIFIDA; LATERAL CURVATURE OF THE CERVICAL, DORSAL OR LUMBAR REGIONS; LUMBAR ABSCESS; RICKETS; FRACTURE AND DISLOCATION OF THE VERTEBRÆ; ANGULAR CURVATURES, INCLUDING GIBBOSITY OF THE ANTERIOR AND POSTERIOR PARTS OF THE THORAX.—In lateral curvature of the spine rejection is demanded if an imaginary vertical line from the centre of the base of the skull falls one

inch on either side of the spinal prominences. Arching of the back, with flattening of the front part of the chest, are disqualifications when they exist to such a degree as to impede respiration or to interfere with the action of the heart. Men frequently present themselves for inspection with shoulders of unequal height. This is generally the result of habit, and is of no consequence unless connected with true curvature of the spine. The degree of this curvature, where it exists, will determine the eligibility of the recruit; but, particularly in peace, recruits with rounded or unsymmetrical shoulders are not desirable, although they may be accepted.

The Ears.—Deafness of One or Both Ears; All Catarrhal and Purulent Forms of Acute and Chronic Otitis Media; Polypi and Other Growths or Diseases of the Tympanum, Labyrinth, or Mastoid Cells; Perforation of the Tympanum; Closure of the Auditory Canal, Partial or Complete, Except from Acute Abscess or Furuncle; Malformation or Loss of the External Ear and All Diseases Thereof, Except Those Which Are Slight and Non-Progressive.—As the distance at which the natural tone of voice may be heard in a closed room, when both ears are normal, is about fifty feet, the distance at which the applicant is to stand from the examiner in testing the hearing must be as great as the apartment will allow, not to exceed fifty feet. The applicant will stand with his back to the examiner, who is to address him in a natural tone of voice. When the distance is less than forty feet, it should be specified on the examination form, and the tone of voice lowered. Failure of the applicant to respond to the address of the examiner will demonstrate a defect. The personal attention of the recruiting officer or sergeant must be given to closing the entrance to each ear separately, by pressing with the thumb the lobe situated in front of the opening to the inner ear. Advantage should be taken of the absence of other sounds to make the examination. Recruiting officers should remember that a man may be totally deaf in one ear, and yet may hear all ordinary conversation perfectly if the sound ear is not completely stopped. Deafness of one ear is a bar to enlistment, but in ordinary occupations it might not be observed. Deafness may be caused by an accumulation of hardened wax; therefore an otherwise desirable recruit should have his ears well cleansed before final action is taken in his case. All men enlisted for the artillery arm of the service at a military post or assigned to that arm from a depot are required, before such enlistment or assignment, besides undergoing the ordinary examination, to be examined especially with a view to establishing the fact of the patency of the Eustachian tubes and the integrity of the tympanic membranes, in default of which the men are unfit for that arm.

The Eyes.—Loss of an Eye; Total Loss of Sight of Either Eye; Conjunctival Affections, Including Trachoma; Entropion; Opacities of the Cornea, if Covering Part of a Moderately Dilated Pupil; Pterygium, if Extensive; Strabismus; Hydrophthalmia; Exophthalmia; Conical Cornea; Cataract; Loss of Crystalline Lens; Diseases of the Lachrymal Apparatus; Ectropion; Ptosis; Incessant Spasmodic Motion of the Lids; Adhesion of the Lid; Large Encysted Tumors; Abscess of the Orbits; Muscular Asthenopia; Nystagmus; Any Affection of the Globe of the Eye or its Contents; Defective

VISION, INCLUDING ANOMALIES OF ACCOMMODATION AND REFRACTION; MYOPIA; HYPERMETROPIA, IF ACCOMPANIED BY ASTHENOPIA; PRESBYOPIA; ASTIGMATISM; AMBLYOPIA; GLAUCOMA; DIPLOPIA; COLOR-BLINDNESS (FOR THE SIGNAL SERVICE ONLY).—The determination of vision requires the greatest care and patience on the part of the recruiting officer; it is made with cards bearing the twenty feet test types and test characters. To use the cards, a distance of twenty feet is measured off in a straight line; place the applicant with his back to the light at one end of the line, while the examiner stands at the other and holds the card exhibiting the test types or characters in full view of the applicant and so that a good light falls on the card. Each eye is examined separately, and if the applicant fails to read the test types or describe the test characters correctly, with either eye, he must be rejected. This standard for vision may be departed from in the examination of candidates for appointment into the Medical Corps of the army and in the enlistment of members of the Hospital Corps, and applicants accepted who are the subjects of refractive errors, viz., myopia, hypermetropia, presbyopia, and astigmatism, provided these errors are not excessive, may be entirely corrected by glasses, and are not progressive or accompanied by ocular disease. The object of this test is to exclude from the service men whose visual defects are such as to prevent them from becoming marksmen. Successful use by the soldier of long-range fire-arms demands that his vision shall be normal or so nearly normal that there need be no question of his ability to see the target at all ordinary ranges. A large percentage of men are the subjects of slight visual defects, not to such an extent as to disqualify them for military duty, but sufficient to cause a little blurring or indistinctness in some of the letters of the required test, which may be increased by the nervous apprehension of failure. Ignorance, stupidity, or fear on the part of an applicant are factors to be considered in making this examination, and unless the recruiting officer exercises sound judgment he will probably reject men whose vision is in reality good; hence plenty of time should be taken and slight errors, such as misreading a P or T for an F, provided the majority of the letters or test characters are read with facility, need not be regarded as failure of the test.

The Face.—NÆVI; UNSIGHTLY HAIRY SPOTS; EXTENSIVE CICATRICES ON THE FACE.—Great deformities of the face—large, livid, hairy, unsightly spots, loss of substance of cheeks—are so many reasons for rejection, as they are calculated to excite aversion and disgust in others; they may prove prejudicial to the service by provoking discontent in the quarters and by exposing the sufferer to cruel and irritating sarcasms and jests that too often end in fatal quarrels. Loss of the nose disqualifies the recruit, not only because it may be the indication of a constitutional disease, but because the consequent modification of voice renders speech unintelligible; and the same objections apply in the case of perforation of the hard palate.

The Mouth and Fauces.—HARE-LIP, SIMPLE, DOUBLE OR COMPLICATED; LOSS OF THE WHOLE OR CONSIDERABLE PART OF EITHER LIP; UNSIGHTLY MUTILATION OF THE LIPS FROM WOUNDS, BURNS, OR DISEASE; LOSS OF THE WHOLE OR PART OF EITHER MAXILLA; UNUNITED FRACTURES; ANKYLOSIS; DEFORMITIES OF EITHER JAW INTERFERING WITH MASTICATION OR SPEECH; LOSS OF CERTAIN TEETH; CANCEROUS

OR ERECTILE TUMORS; HYPERTROPHY OR ATROPHY OF THE TONGUE; MUTILATION OF THE TONGUE; ADHESION OF THE TONGUE TO ANY PARTS, PREVENTING ITS FREE MOTION; MALIGNANT DISEASES OF THE TONGUE; CHRONIC ULCERATIONS; FISSURES OR PERFORATIONS OF THE HARD PALATE; SALIVARY OR BUCCO-NASAL FISTULÆ; HYPERTROPHY OF THE TONSILS SUFFICIENT TO INTERFERE WITH RESPIRATION OR PHONATION.—The condition of the teeth is to be considered solely with reference to the proper mastication of food. If there are not enough in the mouth for this purpose food is swallowed without the necessary preparation, and indigestion with imperfect nutrition and its consequent evils are the result. If several of the teeth are decayed, especially about the crown, it is probable that before the expiration of an enlistment they will be so far destroyed as to render mastication imperfect; hence men who have lost the front teeth from decay and have many unsound back teeth should be rejected. The loss of the front teeth through accident is not cause for rejection, provided a sufficient number of back teeth are sound. Unless an applicant has at least four sound double teeth, one above and one below on each side of the mouth, and so opposed as to serve the purpose of mastication, he should be rejected. Exception may be made by the adjutant general in the case of a soldier who desires to re-enlist, if a report is made showing his age, physical condition as to nutrition, and the number and location of the sound teeth. If the front teeth remain and the double teeth are gone, rejection is demanded. If the loss of the natural teeth is supplied by artificial ones the fact should be noted on the enlistment papers; but the artificial substitutes cannot be considered as equivalent in value to the natural teeth, or as removing the disability on this account for military service.

The Neck.—GOITRE; ULCERATIONS OF THE CERVICAL GLANDS; CICATRICES OF SCROFULOUS ULCERATIONS; TRACHEAL OPENINGS; WRY-NECK; CHRONIC LARYNGITIS, OR ANY OTHER DISEASE OF THE LARYNX WHICH WOULD PRODUCE APHONIA; STRICTURE OF THE ŒSOPHAGUS.—Goitre disqualifies only when large enough to interfere with breathing or the hooking of the collar of the coat, or if recent or growing.

The Chest.—MALFORMATION OF THE CHEST OR BADLY UNITED FRACTURES OF RIBS OR STERNUM SUFFICIENT TO INTERFERE WITH RESPIRATION; CARIES OR NECROSIS OF RIBS; DEFICIENT EXPANSIVE MOBILITY; EVIDENT PREDISPOSITION TO PHTHISIS; PHTHISIS PULMONALIS; CHRONIC PNEUMONIA; EMPHYSEMA; CHRONIC PLEURISY; PLEURAL EFFUSIONS; CHRONIC BRONCHITIS; ASTHMA; ORGANIC DISEASE OF THE HEART OR LARGE ARTERIES; SERIOUS AND PROTRACTED FUNCTIONAL DERANGEMENT OF THE HEART; DROPSY DEPENDENT UPON A DISEASE OF THE HEART.—In measuring the chest the applicant should stand erect without muscular strain or rigidity. After the tape is placed in position and lies snugly and evenly upon the skin, and while the loose ends are held between the fingers of the examiner so that when the chest is expanded the tape will run readily through them, the applicant should be directed to draw in slowly and steadily a long breath until his chest is inflated to its utmost capacity, when the record of chest circumference at inspiration should be read from the tape. He is then to expel the air by counting slowly and steadily from one onward until he can no longer resist the urgent demand for inspiration, when the record of chest circumference at expiration should be

read. This should be repeated several times to insure accuracy. Many men are extremely awkward in developing their chest capacity on demand, and great care and patience are necessary in getting true measurements. It is sufficient to require rejection that the chest should be ill-formed, that its structure should appear to be too weak, and that the other parts of the organism should be stamped with signs "of debility and suffering." It is true the risk is run of rejecting men who may afterward become very robust and who, by a long and successful life, may contradict the opinion that may have been pronounced in their cases; but the army is not a public sanitarium, and "one will be astonished at the number of men who, received because no determinate lesion of the chest was recognized when they were inspected, succumb afterward with consumption, or whom it was necessary to send back to their families with broken health after their strength had been exhausted." A feeble man left at home may become strong; but sent into the ranks he perishes almost certainly. Recently, many cases of so-called "bicycle heart" have been found in applicants for enlistment. These are characterized by hypertrophy, dislocation of apex beat, rapidity and irregularity of rhythm. Such cases are cause for rejection, since under hard service they would probably develop the irritable heart so commonly found in the military service.

The Abdomen.—All Chronic Inflammations of the Gastro-Intestinal Tract, Including Diarrhœa and Dysentery; Diseases of the Liver or Spleen, Including Those Caused by Malarial Poisoning; Ascites; Obesity; Dyspepsia, if Confirmed; Hemorrhoids; Prolapsus Ani; Fistula in Ano; Considerable Fissures of the Anus; Hernia in All Situations.—While hernia itself is a cause for rejection there is found in some men a condition of the parts through which the bowel would pass in the formation of a hernia that is known as "relaxed abdominal rings," and is considered by some surgeons as indicating a tendency to hernia. There is, however, no special evidence to show that hernia follows this condition with greater frequency than it does when the parts are normal. To exclude this class of cases would cause the loss to the service of many excellent men, and it should not, therefore, be considered a cause for rejection. Race exerts a marked tendency on the occurrence of hernia. According to Ssolomka, statistics gathered in the Russian army show that while among the Russians 1 man in every 250 was rejected for this cause, the proportion was 1 to 200 among the Poles, 1 to 175 among the Germans, and 1 to 35 among the Hebrews. Applicants from the latter race are, therefore, to be examined with especial care in this respect. Bleeding or internal piles are always cause for rejection; the external variety, if recent, or if they are old and single, and the applicant asserts that they have never been painful or troublesome, do not disqualify; but if there should be more than one old pile and they are larger than described, or if a single old pile is ulcerated or inflamed, or if there is a small pile associated with varicose veins of the legs, the applicant should be rejected. The flabby folds of skin are not cause for rejection unless very large.

The Genito-Urinary Organs.—Any Acute Affection of the Genital Organs, Including Gonorrhœa and Venereal Sores; Loss of the Penis; Phimosis; Stricture of the Urethra; Loss of Both

TESTICLES; PERMANENT RETRACTION OF ONE OR BOTH TESTICLES WITHIN THE EXTERNAL RING; ANY CHRONIC DISEASE OF THE TESTICLE; HYDROCELE OF THE TUNIC AND CORD; ATROPHY OF THE TESTICLE; VARICOCELE; MALFORMATIONS OF THE GENITALIA; INCONTINENCE OF THE URINE; URINARY FISTULÆ; ENLARGEMENT OF THE PROSTATE; STONE IN THE BLADDER; CHRONIC CYSTITIS; ALL DISEASES OF THE KIDNEY.—A sore upon the head of the penis, in the furrow immediately behind it or on the foreskin, is in the vast majority of instances venereal. This being the fact, the Government is entitled to the benefit of the doubt and these cases should be rejected. The same remarks apply to gonorrhœa. No individual can say positively that an attack of this disease, however mild, will not be followed by a stricture of the urethra. Stricture is frequently a sequence of gonorrhœa, for which reason all cases of this disease should be rejected. Further, it is a contagious disease which should always be excluded from barracks. Other acute diseases, such as swelled testicle, simple inflammation of the foreskin and head of penis, may or may not be of venereal origin; but it is safer to reject the man than to accept him and afterward have him rejected at the second examination or discharged the service at a subsequent date. Phimosis, if marked, is cause for rejection. This condition, although apparently trivial, is occasionally the cause of serious reflex disorders. It interferes with the free discharge of urine and prevents a thorough cleansing of the parts from the natural secretions, which when retained act as an irritant, setting up inflammation and unfitting the soldier for the performance of duty.

Loss of both testicles by extirpation or disease, or marked atrophy of both or special sensitiveness of either, rejects. The absence of both testicles from their natural situation does not necessarily imply the loss of them from either of these causes, for they may never have descended into the scrotum. If the organs have been extirpated by accident or design the scar of the wound will reveal the fact; if they have disappeared from atrophy some rudiment will still remain to show that they have descended. If neither of these signs be present and the testicles are not in the scrotum they are either still in the abdomen or are arrested in the groin, where they may be felt and possibly seen as tumors or lumps, and may be distinguished by the peculiarly sickening pain felt when they are vigorously squeezed between the fingers. If they occupy any portion of the groin they incapacitate the man from their liability to be followed by rupture, and particularly from their exposure to painful injury and to strangulation; but if they are within the abdomen, and the man appears vigorous otherwise, the condition may be disregarded. These remarks are also applicable to those cases in which only one testicle is present in the scrotum.

Varicocele, when slight, is not a cause for rejection; but it is presented to the examiner in so many degrees of development—from an almost imperceptible enlargement of a few of the veins to a condition in which all of them are swollen as large as goose quills and completely fill, by their mass, the scrotum—that the determination of the cases would be most perplexing, even to a medical expert, but for the rule formulated by Tripler, which, if strictly followed, will exclude from the service men thus physically unfitted. This rule is as follows: "If the testicle upon that side is atrophied, whatever may be the volume of the cirsocele, or if the

volume of the latter exceeds that of the former, the recruit should be rejected." Of 9,901 men examined for the volunteer service in 1898, varicocele, in varying gravity, was found in 21.17 per cent. Of all these cases only 6 caused rejection. It should be remembered that varicocele is markedly aggravated by service in hot climates.

Affections Common to Both Upper and Lower Extremities.—Chronic Rheumatism; Chronic Diseases of the Joints; Old or Irreducible Dislocations or False Joints; Severe Sprains; Relaxation of the Ligaments or Capsules of Joints; Dislocations; Fistulæ Connected with Joints or Any Part of Bones; Dropsy of Joints; Badly United Fractures; Defective or Excessive Curvature of Long Bones; Rickets; Caries; Necrosis; Exostosis; Atrophy or Paralysis of a Limb; Extensive, Deep, or Adherent Cicatrices; Contraction or Permanent Retraction of a Limb or Portion Thereof; Loss of Limb or Portion Thereof.—It is a matter of primary importance that the soldier should have the perfect use of all his limbs, and that the completeness and integrity of these organs should be in no wise impaired. Careful inspection of the limbs, even to the most minute detail, will therefore not be neglected by the officer who feels a proper interest in the good of the service or in his own reputation. Old dislocations, usually occurring in the upper extremities, if attended by any impairment of motion or distortion of the joint are cause for rejection. The applicant for enlistment will, of course, put the best face on the results of these cases and stoutly assert that the joint is as good as ever; but he should in all cases be tried with a rifle, to see if he can perform quickly and easily the various motions required in the manual of arms and in the set-up drill. Even if motion is perfect it is doubtful policy to enlist a man who has any amount of distortion from a dislocated joint, because he has enough of a visible defect upon which at any time to hang an excuse for a discharge if from any cause the service becomes irksome to him. Fortunately, badly damaged joints are easily discovered, and the safest plan in such cases is to reject, even if the distortion or loss of motion be ever so slight. The same general remarks will apply to important fractures, especially if they have been in the neighborhood of joints. If followed by wasting of limb or paralysis there can be no doubt about the necessity for rejection.

The Upper Extremities.—Fracture of the Clavicle; Fracture of the Radius and Ulna; Webbed Fingers; Permanent Flexion or Extension of One or More Fingers, as Well as Irremediable Loss of Motion of These Parts; Total Loss of Either Thumb; Mutilation of Either Thumb; Total Loss of the Index Finger of the Right Hand; Loss of the Second and Third Phalanges of All the Fingers of Either Hand; Total Loss of Any Two Fingers of the Same Hand.—Rejection is necessary when there is mutilation of either thumb to such an extent as to produce material loss of flexion or strength of the member. The common distortion of the extremity due to contusion or felon need not disqualify. Special care should be used in the examination of the thumbs with a view to the ability of the applicant to use them in cocking the rifle. Permanent partial flexions of the little finger of one or both hands, due to the effect of some particular varieties of labor, do not disqualify, as they in no wise interfere

with the prompt and effective handling of arms. The permanent flexion of any other finger does, and should exclude from service. Redundant fingers are not always objections to a recruit. If the redundant finger is upon the outer border of the hand it is not usually in the way, and particularly if it be the left hand.

The Lower Extremities.—Varicose Veins; Knock-Knees; Club-Feet; Splay or Flat Feet; Webbed Toes; the Toes Double or Branching; the Great Toe Crossing the Other Toes; Bunions; Corns; Over-Riding or Superposition of Any of the Toes to an Extreme Degree; Loss of a Great Toe; Loss of Any Two Toes of the Same Foot; Permanent Retraction of the Last Phalanx of Any of the Toes, or Flexion at the Right Angle of the First Phalanx of a Toe upon the Second, with Ankylosis of the Articulation; Ingrowing of the Nail of the Great Toe; Stinking Feet.—In young men, the development of varicose veins to a degree of prominence that would warrant especial attention is rarely met with; it is more commonly found in men of thirty years and upward, particularly in those of intemperate habits or of feeble constitution. Mechanical obstruction to the flow of the blood through the veins may also be the cause. Moderate prominence of the veins in men who are otherwise healthy, and who are temperate, need not disqualify; but it must be borne in mind that the tendency of this affection is to become aggravated, particularly in tall men, and upon long marches with knapsacks and arms. The character, then, of the veins should be well noted. Sometimes the minute superficial branches only are enlarged. This is particularly the case in the space behind the knee and on the inside of the thigh, and is in itself of no consequence; but when clusters of knots are seen, or one or more single knots, large and with thin walls, or a network of enlarged branches are found about the ankle, the back of the foot, the calf of the leg, the ham of the thigh, or distinctly enlarged veins exist, that are not necessarily knotted, especially if extending above the knee, the man should be rejected. In all cases when there is chronic tumefaction, dropsy of the limbs, or marks of ulceration, rejection is demanded.

The condition known as "knock-knee" sometimes, though rarely, exists to such a degree as to unfit a man for military service. When disqualifying, it is impossible for the man to take the position of a soldier, and he is anatomically disabled from performing a long march. It would be said generally that if a recruit cannot bring the inner borders of the feet, from the heel to the ball of the great toe, within one inch of each other without passing the inner surface of the knees respectively in front of and behind each other, he is unfit for service.

With regard to flat feet, the condition that renders a man unfit for service is that in which the arch is so far effaced that the entire inner border of the foot rests upon the ground; the inner ankle is very prominent, as is also the bone of the foot articulating with it, and the axis of the leg does not fall upon the centre of the foot—giving the effect that the ankle-joint has been dislocated and the foo t crushed down and outward. This extreme degree of splay or flat foot is not often seen; a broad and flat sole is common to the laboring classes, and particularly so among negroes; but, unless an ill-fitting shoe is worn, this shape of the foot is not more

likely to induce disability in long marches than is the arched foot of a more shapely mould.

Rejection follows over-riding or superposition of any or all the toes to a degree that renders the wearing of a shoe painful; permanent flexion of the last joint of one of the toes (hammer toe) so that the free border of the nail bears upon the ground, or flexions at a right angle of the last joint of a toe (usually the second toe) upon the second, with stiffness of the joint; ingrowing nail of the great toe, usually the outer side, if deep and accompanied with signs of inflammation or ulceration.

Re-Enlistments.—When authorized by the War Department, the recruiting officer is permitted to accept men desiring to re-enlist and who present themselves for that purpose within the prescribed limit, "notwithstanding they may have some physical disqualification which would cause their rejection as recruits, provided they have no serious defect which would probably prevent the discharge of their duties as soldiers. In all such cases the defects and the fact that they existed prior to re-enlistment will be noted on the soldier's enlistment papers." In modifying its requirements for enlistments in this particular, it is the intention of the War Department to provide for the continuance in service of such faithful soldiers as have incurred disabilities during prior enlistments, which either do not or probably will not unfit them for duty in the future.

Rejections.—Of the applicants for enlistment a considerable proportion are summarily rejected by recruiting officers, prior to any physical examination, by reason of intoxication, obvious defect of body or mind, or on account of apparently undesirable personality. Such rejections are not made a matter of official record. Of those admitted to the physical examination only about one in four has been found in times past to be qualified for the military service. In the five years 1889–93, the total number of applicants physically examined was 101,432, and of this number 85,136 were rejected, while 26,296, or 25.92 per cent., were accepted.

During the past decade the physical attributes of the classes from which recruits were derived appear to have undergone steady improvement, the enlistments for the year 1897 showing the proportion of 702.19 accepted as fit for service per thousand examined. The colored applicants for enlistment have a somewhat higher physical average than the whites, the rate of acceptances per thousand examined being 786.71 for the former as against 695.16 for the latter.

The causes of rejection on the primary examination with ratio per thousand of the 62,029 men examined, covering the four years 1894–97, are as follows:

Year.	1894.	1895.	1896.	1897.	Average.
Total number examined	16,586	17,645	14,659	13,139	15,507
Venereal disease (rate per 1,000)	14.89	14.96	16.10	10.80	14.19
Other infectious diseases do.	2.77	6.97	3.27	1.75	3.69
Diseases of nutrition, general do.	.36	.68	.27	.30	.39
Diseases of the nervous system do.	.78	.74	.48	.61	.65
Diseases of the digestive system do.	33.40	37.75	21.15	12.48	26.19
Diseases of the circulatory system do.	36.47	52.08	30.36	27.55	36.61
Diseases of the respiratory organs do.	.84	2.83	1.02	1.52	1.55
Diseases of the genito-urinary system do.	41.30	40.92	33.36	23.52	34.77

Year.	1894.	1895.	1896.	1897.	Average.
Diseases of the lymphatic system and ductless glands .....(rate per 1,000)	.72	2.49	1.84	1.83	1.72
Diseases of muscles, bones, and joints do.	5.37	5.44	4.57	4.11	4.87
Diseases of integument and subcutaneous connective tissue.....do.	8.80	7.76	8.53	5.10	7.55
Diseases of the eye.....do.	77.72	59.67	51.50	37.14	56.50
Diseases of the ear.....do.	5.25	6.63	4.09	4.26	5.05
Diseases of the nose.....do.	2.47	.91	1.98	1.14	1.62
Hernia.....do.	7.72	11.50	6.75	5.33	7.82
Other injuries.....do.	4.40	5.04	3.96	2.97	4.09
Over height.....do.	.36	.11	.48	.30	.31
Under height.....do.	19.77	8.50	5.46	4.19	9.48
Over weight and obesity.....do.	4.04	2.15	3.55	1.98	2.93
Under weight.....do.	46.00	36.50	44.00	26.41	38.26
Imperfect physique.....do.	68.61	86.54	61.87	58.98	69.00
Mental insufficiency.....do.	1.39	1.53	1.30	.83	1.26
Over age.....do.	4.64	2.49	1.16	.61	2.22
Minors.....do.	14.29	14.39	11.94	4.64	11.31
Married or having dependent relatives do.	3.62	2.78	3.34	1.83	2.89
Illiteracy.....do.	6.75	9.80	5.93	1.37	5.96
Imperfect knowledge of English.....do.	16.64	6.23	4.16	.23	6.81
Re-enlistment disapproved .....do.	3.32	1.19	.55	2.13	1.80
Character bad or doubtful.....do.	9.95	10.43	7.37	5.10	8.21
References none or unsatisfactory....do.	21.46	7.88	10.98	5.63	11.49
Aliens.....do.	3.56	4.25	1.91	.61	2.58
General unfitness.....do.	31.35	20.01	11.94	7.15	17.61
No vacancies .....,do.	8.08	.17	1.91	.53	2.67
Unclassified .....do.	3.56	2.10	4.57	2.82	3.26
Total per thousand	510.67	473.45	371.65	265.77	405.38

During the war with Spain an unusually good class of young men presented themselves for enlistment in the volunteer service. Out of 9,901 members of the Illinois National Guard who offered themselves for the United States service only 747, or less than 8 per cent., were rejected as being physically disqualified. It is proper to say that these men had already been examined for their militia service; which examination, though not rigid, had eliminated the more obviously unfit. The causes of rejection, as compiled by Adams, were as follows:

General Constitutional Conditions.—Poor physique, 177; rheumatism, 13; syphilis, 14; tubercular diathesis, 3; premature senility, 4; obesity, 6; ancient sunstroke, 5; pediculosis, 2; chronic alcoholism, 1; chronic cutaneous affections, 3; asymmetry, 1; not stated, 6.

Eyes.—Myopia, 13; strabismus, 10; defective vision, precise condition not stated, 35; leucoma, 6; keratitis, 1; tumor of orbit, 1; purulent conjunctivitis, 2; trachoma, 1; artificial eye, 1; cataract, 1.

Ears.—Otitis purulenta, 21; defective hearing, 24; mastoid abscess, 2.

Teeth.—Extensive caries, 18; extensive loss of, 30.

Nose.—Rhinitis, chronic, 1; dermoid cyst, 1; deformity with obstruction, 1; chronic pharyngitis, 2.

Throat.—Chronic laryngitis, 2.

Neck.—Tubercular adenitis, 3.

Chest.—Deficient expansion, 6; consolidation of lungs, 7; mitral lesions, 15; weak heart, 1. Deformities: Flat chest, 6; rachitic, 14; muscular atrophy, 2; old gunshot wound, 3; deformity not specified, 2; chronic ulcer of, 1.

Spinal Column.—Curvature, 4.

Upper Extremities.—Ankylosis of shoulder, 2; ankylosis of elbow, 2; synovitis of elbow, 1; loss of fingers, 4; ankylosis of fingers, 4; drop-wrist, 1; deformity not specified, 1.

Abdomen.—Hernia, oblique inguinal, 129; ventral following operation, 2; recurrent and chronic appendicitis, 12; pot-belly, 3; chronic diarrhœa, 1.

Genitals.—Varicocele, large, 5; varicocele with atrophy of testis, 1; hydrocele, painful, 8; cryptorchid, partial, painful, 1; tubercular testis, 2; epididymitis, 2.

Venereal Disease.—Gonorrhœa, 18; gleet, 1; suppurating bubo, 1; chronic orchitis, 1.

Lower Extremities.—Talipes, 3; flat feet, excessive or painful, 33; varicose veins, 22; varicose ulcer, 3; unhealed gunshot wound, 1; deformed toes, 4; ununited fracture of great toe, 1; bunions, 1; corns, 1; ingrowing nail, 1; ankylosis of hip, 1; synovitis of knee, 3; loss of foot at ankle-joint, 1.

Of the recruits examined for the British service in 1893 an average of 405.54 per thousand were rejected. The most frequent cause for rejection was defective development—the ratio being 181.78 per thousand; while impairment of vision was the next frequent disability and accounted for 41.51 rejections per thousand. Heart affections, diseases of veins, loss of teeth, and defects of the lower extremities were among the other causes and were arranged in the order given.

Marshall divides the causes on account of which recruits are rejected into three classes:

1st. Diseases or deformities which a medical man from his professional training and acquaintance with the duties of the soldier considers are infirmities which disqualify men for service in the army.

2d. Slight blemishes which do not disqualify a man for the army but which an unwilling soldier may exaggerate, and allege that he is thereby rendered unfit for military duty.

3d. Unimportant details or deviations from symmetry, or slight variations from the usual form or condition of the body—technical or nominal blemishes which do not incapacitate a man for the army or in the slightest degree impair his efficiency.

As stated by Greenleaf, experienced surgeons will reject all recruits whose defects fall under the first two headings from a conviction that they render the men unfit or undesirable for the army; but those under the third head are frequently rejected from fear of responsibility, a dread of official correspondence and to an ultimate damage to professional character. In time of war those coming under the first head should be excluded, while those coming under the second and third heads should be as rigidly held in the service.

CHAPTER II.

THE DEVELOPMENT OF THE RECRUIT.

I.

GENERAL CONSIDERATIONS OF PHYSICAL TRAINING.

STRENGTH, activity, endurance and discipline, combined with sound bodily health, are the first requisites of the soldier; the foundation upon which the whole structure of military efficiency rests. These qualities may be largely obtained by a scientific system of physical training, regulated by the fitness of those who undergo it, progressive in character and calculated to develop the body to its full power and perfect conformation. As applied to the recruit, physical training has a special technical value; since, in addition to the qualities enumerated above, it does much to perfect him in military duties and exercises, instructs as to the best manner in which to overcome the possible contingencies of actual warfare, and greatly aids to bring about that peculiar state of endurance and habit by which the soldier is enabled to support the labors and requirements of the military service. "It is false economy on the part of the nation and cruelty to the men to expose them to the privations of war and the fatigue incident to campaign without fortifying their constitutions and providing that reserve of strength, vitality, and endurance upon which they must draw and without which they will break down."

If to physical ability be added the faculties of quick perception and prompt execution, the combination is of infinitely more value than the same amount of sluggish muscle piled on the back of a listless and indifferent mind and an irresolute and halting will; these mental virtues being best developed by varied movements rapidly performed in obedience to the word of command. In the absence of such mental qualities it will prove of but little value to drill and instruct the soldier.

The Untrained Recruit.—In time of peace the methods of recruiting employed in the army of the United States prevent the entrance into the service of men with muscles clearly undeveloped or such as are distinctly atrophied as the result of disease. Still, it is by no means uncommon that men are enlisted with defects or deficiencies sufficiently pronounced to exert a considerable influence on their health or value as soldiers during their term of service. Previous hard manual labor is far from being the equivalent of intelligent physical training. The deformities of occupation, due to the excessive use of one portion of the body and neglect of others, are well recognized; and variations of structure from this cause are so frequent that but a trifling proportion of accepted recruits are fairly symmetrically developed. The ideal soldier is a man of commanding presence, erect stature, broad shoulders, strong, graceful and neat; and the

raw material from which these ideal conditions must be evolved is well shown in Prince Hohenlohe's graphic description of the men obtained in the recruitment of his own regiment: "The barracks were soon full of figures that would put to shame the most exaggerated cartoons of the comic papers. The awkward fellows, whose neglected carriage made them look like a set of botched-up images, tried hard, but in vain, to stand erect. Ill-made and ill-developed, their uniforms would not fit them, and if altered to suit their present figure would need to be remade when they should be remodelled by physical training. So, before teaching them a single movement of the military drill or providing them with uniforms other than their canvas fatigue suits, they were drilled in gymnastic exercises leading progressively and gently from the more easy to the more advanced, until finally they had reasonable command of themselves."

In such lack of harmony between various parts of the body lies a source of marked physical weakness in the recruit. The well developed chest and arms in the average recruit are more than likely to be accompanied by spindling legs; while the limbs of the left side are usually smaller than those of the right, an asymmetry which extends to numerous other details. As a general rule, weight, height and breadth may be said to be in direct proportion to the strength—but exceptions are numerous and pronounced. Weight may be due to an excess of adipose tissue, tending to produce debility rather than strength. Height may be due to excessive length of legs or neck, both elements of weakness; while breadth may unite with it flabby muscles and fatty deposits. Few recruits, if indeed any, are enlisted in whom devleopmental deficiencies are not at once apparent.

Determination of Defects.—Accurate examination of the recruit will show his deviation from the normal type, from which the exercises necessary to assimilate him to the physical mean will be a natural deduction. In this connection mensuration, inspection, and palpation are of particular importance; but mensuration alone may lead to error in that one group of muscles may be over-developed so as to neutralize, in the measurement of a limb, the effect of the atrophy of another. The preliminary data upon which to base the physical training are, in the larger colleges, obtained by a considerable number of measurements; but this method, while eminently scientific and satisfactory in its results, is much too laborious and minute to be of practical application for the military service. In general, a proper course of training may be readily and satisfactorily outlined as a result of simple but careful inspection of the individual. It should be remembered, however, that it requires most accurate anatomical knowledge to select the individual muscle to which a defective part owes its weakness or lack of symmetry. Not only is correct appreciation of its function necessary to understand the particular movement or combination of movements adapted to the development of a defective muscle, but to secur ethe best results there must be familiarity with its secondary and remote effects upon portions of the system. Hence proper physical training requires the careful supervision of an educated instructor to direct the exercises to the needs of the particular individual, and thus prevent the harm that may arise from the unintelligent and injudicious use of what in well directed channels is a most important agent

in the attainment and maintenance of structural development and physical health.

Exercise in Relation to Muscular Development and Power.—Exercise is usually regarded as implying action of the voluntary muscles alone, but in its effects it has a far wider range of application. Movement of the voluntary muscles is accompanied by corresponding action of the involuntary muscles; and the condition of these, their health, and the activity of their physiological processes, depends greatly upon the impulses excited by voluntary motion. Every organ in the body is capable of being exercised directly or indirectly, and in such as are not properly brought into action an abnormal state is certain to ensue ultimately. As remarked by Aitken, "All the parts of the organization of man are connected and correlated so that with the increased or diminished dimensions of the whole body, or any particular part of it, certain organs are increased, diminished, or modified; and modifications which arise during the earlier stages of growth tend to influence the subsequent development of the whole man."

Exercise increases the size and voluntary power of the muscles employed. It accustoms these to unusual and extended effort and at the same time develops other muscles to assist in the execution of more complex movements. Under exercise against resistance the muscle increases in its nitrogenous constituents, growing by hyperplasia and becoming stronger. Such trained muscles are harder than the untrained, probably because of the increased power of simultaneous contraction acquired by the fibrillæ.

Within a certain limit, resistance to the shortening of a muscle makes it more able to shorten, and greater extension of the muscle places it in a state in which it can contract more powerfully. Hence, to be of the most value, exercise should consist of movements of sufficient force to necessitate energetic muscular contraction. Actual work must be accomplished, and the muscles should be so used that the exercise is felt and fatigue is noticed. This requirement necessitates resistance as an element, and hence physical exercise may be defined as voluntary labor. Resistance is necessary to obtain proper contraction of the muscles, the contraction for their molecular disintegration and the disintegration for their renewal, since upon the constant destruction and breaking down of tissue depends the subsequent renovation upon which the strength and vigor of all parts of the body depend.

Exercise as Affecting the Nervous System.—In addition to its effect on muscle, exercise may be employed to produce prompt co-ordination or for its effects on the nervous centres, which are quite as important as those upon the muscles. Proper physical training favors a symmetrical brain development, as exercise of the function of the centres governing the action of the muscles must favor the growth and development of those centres. Bodily exercise does not interfere with mental activity, and all nervous functions are by it improved in tone.

Influence of Exercise Upon the Heart.—As a result of exercise the action of the heart is increased in both force and frequency. The heart stimulus is due to the increased amount of blood in its cavities, and the venous circulation supplying this blood is largely influenced by muscular

action. "Every muscle is a little heart," and these by their contraction constantly tend to drive the blood on to the true heart and lungs. Exercise produces an enlarged heart; this being due to the fact that it is a muscular organ, and shows with other muscles both the fatigue due to violent and prolonged exertion, and also the increase in size and power due to proper exercise and nutrition. "The fatigue results in dilatation, the increased power in hypertrophy, and one of the main objects of training is the establishment of this hypertrophy."

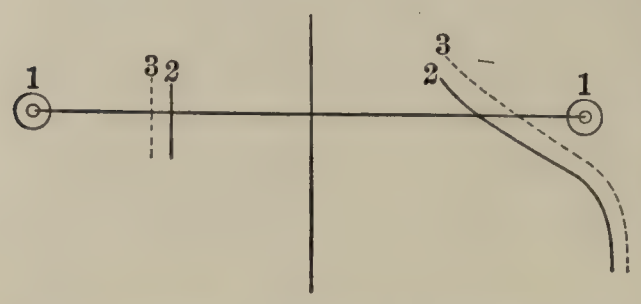


FIG. 1.—Average Dilatation of Heart, Harvard Boat Crew, after Race. 1, Nipples; 2, before race; 3, after race. (After Darling.)

The degree of dilatation following severe exertion is more marked in the young and inexperienced than in those who are well trained, and it is in the former class that acute dilatation, sufficient to cause cyanosis, is sometimes observed. Such an accident, occurring in the untrained, may often result in permanent injury; while under the same circumstances the experienced athlete might recover apparently complete compensation in a few hours or days. To over-exertion, as in forced marches, is ascribed the condition known as "irritable heart." Hypertrophy, rather than dilatation, follows long-continued exertion of low grade; while sudden effort, when severe, has been known to rupture a valve or weakened heart-wall. Hence the circulatory organs should be carefully trained before their powers and endurance are severely tested. The effect of continued and severe exercise being cardiac hypertrophy, persons who have such enlarged hearts frequently present symptoms of over-compensation after the cessation of training. Under such circumstances the heart and arteries must re-adjust themselves to changed conditions, and there is some risk accompanying the degeneration by which this is accomplished.

As a result of severe exercise, particularly when long sustained and carried to the point of extreme exhaustion, valvular murmurs of functional character are of frequent occurrence. The cause of these murmurs, in acutely dilated hearts, has been well studied by Williams and Arnold—no evidence having been advanced contrary to their conclusion that the bruits are of mitral origin, and are due partly to a relaxation of the circular muscular fibres surrounding the orifice, and partly to fatigue of the papillary muscles which control the movements of the valve cusps. These observers found such cardiac murmurs in eleven out of thirteen contestants in a long-distance run examined by them.

As long as the heart is not overtaxed the pulse beats are regular and even, though suddenly increased exertion may make the rate very rapid; but the ordinary military exercise, when properly conducted, should not, after a course of preliminary training, increase the pulse rate more than fifteen to thirty beats a minute. If at the beginning of a new exercise the heart action becomes irregular, the work should be discontinued and later recommenced in a more gradual way. Loss of breath is due to cardiac embarrassment together with fatigue of the respiratory muscles. After unusual effort, provided that the exercise be not too greatly prolonged, the pulse is invariably of high tension; but if the exhaustion be extreme the arterial tension falls much below the normal. It is to be remembered that

the physiological capabilities of the heart are enormous, and in judging of the effect of any undue exertion on it, the murmurs and irregularity must not be alone considered, but also the way in which the heart is doing its work, its strength, as shown by its ability to maintain a proper arterial tension, and its recuperative power. As with other muscles, not size but quality tells in the long run.

Exercise in Relation to the Chest and Lungs.—The chest is the most essential factor of a soldierly physique. Its development necessarily includes that of other portions of the body, for no one can perfect the capacity, bony frame and muscles of the thorax without also developing the back, loins and limbs. A capacious and mobile chest almost invariably means stout arms and, to a certain degree, good legs.

During muscular action there is an increased demand for, and consumption of, oxygen and an increased production and elimination of carbon dioxide and other waste material. This demand for better aëration of the blood necessitates a considerably increased activity on the part of the respiratory organs—a man marching at the rate of four miles per hour inspiring five times as much air as when reclining at rest—and this is one of the greatest advantages of physical exercise. Respirations are by it increased in frequency and depth, the lungs expanded, the air vesicles flushed out and refilled. Consequently the movements of any given exercise should be with speed and force enough to deepen and quicken the respiration; and conversely, if any severe exercise is to be undertaken or a course of training begun, especial care must be had to develop the lung capacity. Since action of the muscles is checked and rendered less vigorous if the carbon dioxide produced by their action is not immediately carried off by the blood and eliminated by the lungs, it follows that during exercise there should be nothing to impede the circulation or action of the chest or lungs, and that all tightness of clothing, especially about the waist, chest and neck, should be avoided. Respirations fall during sleep and appear to bear some relation in their frequency to the energy liberated; the production and elimination of carbon dioxide under exercise being particularly large in recruits inclined to obesity.

Among recruits, even if the chest measurements be satisfactory, shallow respiration is a common defect. The lungs are habitually only partially expanded, and in consequence, through absence of reserve power and the lack of air in excess of actual ordinary needs—the result of inadequate vesicular dilatation—the individual becomes winded upon unusual or prolonged exertion. Breathing exercises, with voluntary forced expansion and contraction of the chest, are most difficult of accomplishment by this class of men, they appearing to possess only to a limited degree the power of conscious control over the muscles of respiration. As the lungs contain little air beyond immediate respiratory needs, so the muscles of the chest are but little developed in excess of ordinary demands, and their free unembarrassed action is the exception. The common and incorrect method of breathing among recruits consists in filling the upper and middle parts of the lungs at the partial expense of the lower. The collar bone and shoulders are raised, as is also the upper part of the chest. There is a slight movement upward and outward of the chest, while the lower part of the lungs remains passive, the diaphragm being but little used. As a re-

sult of proper training a large portion of the lungs is utilized which is never used by persons of sedentary habits, the whole of the lungs and not merely the upper half being brought into action. When breathing is correctly performed there is no movement of the clavicles and shoulders, but merely an upward and forward action of the sternum, more especially the lower part, combined with elevation of the ribs and with abdominal contraction and relaxation. Abdominal breathing should be particularly cultivated; it not being forgotten that the diaphragm is as amenable to training as is any other muscle. The lungs should be filled slowly and emptied forcibly, regularity in this exercise soon increasing expansion and serving as an excellent aid in securing an erect, manly carriage and dignified gait. The increase of lung capacity depends largely on thoracic mobility; an originally mobile chest, even if of small dimensions, favoring it greatly. Generally speaking, the younger the recruit the better the results which may be anticipated in this respect.

The habit of breathing properly is a great factor in longevity, and a roomy thorax and strong heart are no mean allies in resisting invasion by disease. When the latter has actually gained a foothold a few additional cubic inches of respiratory capacity or a small reserve of disciplined cardiac power may suffice to turn the scale in pneumonia or typhoid fever. It is true that many comparatively undeveloped persons enjoy fair organic health, but it is equally true that greater respiratory and muscular power would unquestionably make such lives more effective and of longer duration. The influence upon the system of enlargement of the chest cannot be overestimated. The greater expansion permitted to the lungs, the greater play allowed the heart, the greater amount of oxygen introduced into the system, the greater excretion of effete matter from the blood—all these exert a powerful influence for well-being upon every cell of which the body is composed. To be truly strong the individual must be able to breathe deeply and well, and nothing is more certain in the military service than the dictum that "every inch a man adds to his chest measure adds to the measure of his days."

Abel found in seventy-five out of one hundred soldiers, examined after a course in physical training, that the chest measure was increased from 2.6 to 5 cm. Marey noted among the men under instruction at Joinville-sur-Pont that while after a six months' course of training the frequency of the respiratory movements was actually decreased, there was a notable increase in the amount of air inspired in a given time; the examination of a large number of men by means of the spirometer showing an average increase of respiratory capacity of 500 c.c.—rising from 3,800 to 4,300 c.c. At the end of the course of instruction he observed that exercises which at the outset had rapidly induced breathlessness and exhaustion were readily performed with little or no acceleration of breathing.

In the British service the drill sergeant endeavors not only to expand the chest but to keep it expanded. The recruit is required to hold himself upright with the head well back and the chest inflated by the fullest inspiration, and this artificial dilatation is sought to be maintained without giving place to a corresponding exhalation. In this condition, as analyzed by Davy, the expiration, being held in abeyance, obstructs the circulation and impedes the cardiac action. With imperfect respiration the aëration

of the blood becomes imperfect, the abdominal muscles are weakened by overstrain and their action is impeded by forced depression of the diaphragm, while the increased measurement of the chest of the recruit is secured at the expense of its mobility and at the risk of emphysema. In this distended chest the heart is displaced downward, the area of the impulse is increased, the beat is jerky and too powerful and may reach 110, with irregular force and time. This training is persevered in from day to day, making picturesque soldiers at the expense of their weakened vitality.

Training for strength and training for wind are two different things, attainable by quite different means. Exercises which best favor development of the chest are those which relate to the upper extremities, and hence a course of gymnastic training is of particular value in the attainment of this object. All track athletics also must be considered as respiratory exercise, and rapidity of performance adds to any movement the element of respiratory effort. A light dumb-bell may be lifted and grounded so slowly as scarcely to quicken the respiration, or so rapidly as severely to test the wind. The voluntary muscles do no more work in one case than the other, but the involuntary muscles may do twice as much. Hence such efforts should always be preceded by scientific training.

Exercise as Affecting the Kidneys.—As regards the effect of hard exercise upon the kidneys, Darling noted the occurrence of a slight increase in the excretion of urea—this probably being due to an increase in proteid digestion and not to an increase of muscular action. In his investigations upon the Harvard University crew for 1898 he found that a small amount of albumin persisted during ordinary training, while after racing the quantity was greatly increased. Under the latter conditions the sediment contained large numbers of hyaline and finely granular casts, many having renal cells and blood corpuscles adherent. This sediment was in many cases exactly like that in the first stages of an acute nephritis. The renal conditions during severe exercise he believed might be interpreted as an active hyperæmia, becoming intense during extraordinary effort, and probably dependent on increased arterial tension. Whether such hyperæmia ever leads to permanent changes in the kidneys is a matter to be determined by future investigation. Apparently opposed to the above are the results obtained by Forrest from an exhaustive examination of the urine of 142 British soldiers, healthy and free from gonorrhœa, and marching from ten to twenty miles daily under full field equipment. He found that out of the 142 men, 14 presented albumen in the urine prior to beginning the march. In 9 of these 14 cases albumen was not subsequently found, on testing for it both before and after the daily march. The invariable effect of the day's work was either to abolish the albumen found before the march or to lessen the amount excreted. Marching exercise, however, is protracted, and in it the element of sudden and severe exertion is absent. Between the steady but low-grade expenditure of energy in the one, and the brief but supreme effort required in boat-racing, it is evident that legitimate comparisons are impossible.

Weight as Affected by Exercise.—It has long been recognized by athletic trainers that weight is one of the best indicators of condition. At the beginning of training a man always loses weight in fat, but it is usually more than regained later in increased muscular development, provided

sufficient food is given in proportion to the exercise taken. Ordinarily recruits gain weight, not lose it. Ammon, in a series of observations carried on upon a regiment of Baden grenadiers, found an increase in weight under exercise of about 2 kgm.; almost identical results being obtained by Abel. At the gymnastic school of the French army at Joinville, as the result of the careful observation of eighty men, Burg saw the weight go up on an average of from 6 to 10 kgm., and believed that this increase was due exclusively to muscular development. The results last mentioned, however, were obtained with selected men placed under conditions far more favorable to development than are found in ordinary military life, and such an unusual increase in weight is not ordinarily to be anticipated by the instructor. Recruits as a class are not of an age or habit in which their weights can be greatly reduced by properly administered exercise, the greatest loss of weight naturally occurring in

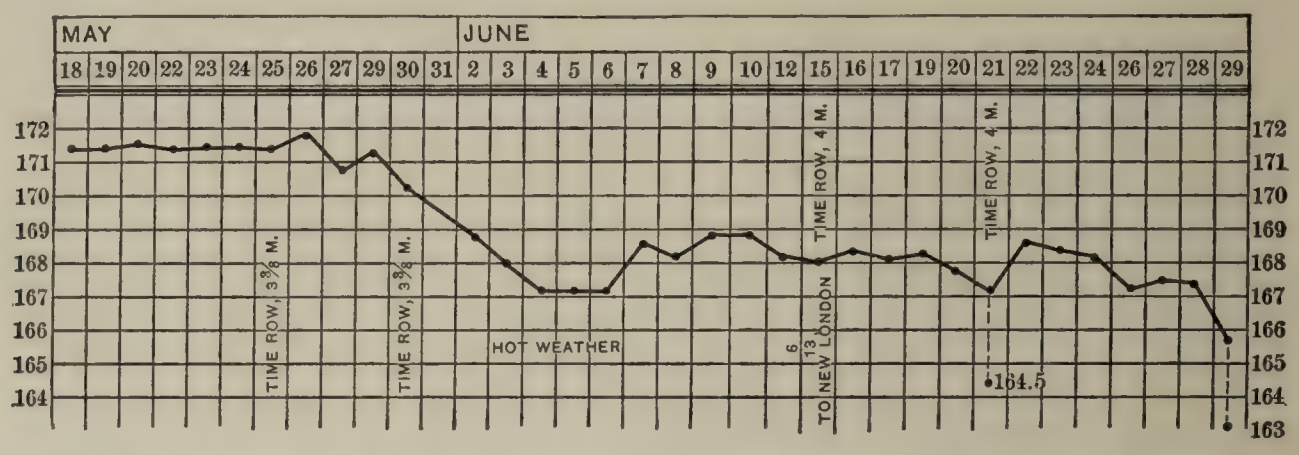


FIG. 2.—Average Daily Weight of Harvard Boat Crew under Training. (After Darling.)

men of large girth and superabundant fat. Extraordinarily hard and exhausting exercise, even with conditioned athletes, when continued induces a certain loss of weight, as evidenced in the accompanying chart.

Brief exercise, if severe, may result in considerable temporary diminution of weight. Maclaren observed upon himself that as a result of an hour's energetic fencing the loss in weight amounted to about forty ounces, of which about thirty-six ounces remained in the clothing as perspiration. When the exercise is more protracted and the individuals are unused to such labor, the results are for the time similar. In the First Munster Regiment the weights in one company were taken by Barry before and after a six days' practice march at the Curragh. It was found that: 7 men did not vary in weight; 12 lost one pound; 4 lost two pounds; 6 lost three pounds; 1 man lost four pounds; 3 men lost five pounds; 1 man gained one-half pound; 8 men gained one pound; 3 gained two pounds. The net loss of the 47 men was 42.5 pounds, or a trifle over three-fourths of a pound per man.

A loss of several pounds during prolonged exertion does not by any means imply an undue degree of exhaustion, provided the individual is in good condition. The men who lose most are usually fully as vigorous as their companions. It is generally accepted on experimental grounds that during active exercise the energy is largely if not wholly derived from the oxidation of fat and glycogen, and that the muscles themselves are not used up in the process. The end-products of this combustion—chiefly water and carbon dioxide—are rapidly excreted through the lungs and

skin. The loss of weight represents very closely, therefore, the amount of fuel used up. Hence the man who has an adequate supply of reserve fuel in the form of fat and glycogen is in better condition to withstand a prolonged exertion than one who is deficient in those substances. This corresponds with the experience of all athletes. There is always a loss of weight during the early part of training, while a man is getting rid of the superfluous fat; but every athlete knows that when a certain point is reached—his so-called "weight in training"—any further reduction is accompanied by a feeling of lassitude and an incapacity to sustain prolonged exertion without excessive fatigue. This form of over-training, known as "staleness," is in all probability due to a deficiency of reserve fuel. These facts emphasize the importance of maintaining at a proper proportion the fat and carbohydrate constituents of the dietary instead of sacrificing them for an excess of nitrogenous material—a mistake which is undoubtedly often made.

Exercise as Affecting the Functions.—Exercise greatly increases the amount of perspiration, the evaporation of this surface moisture main-

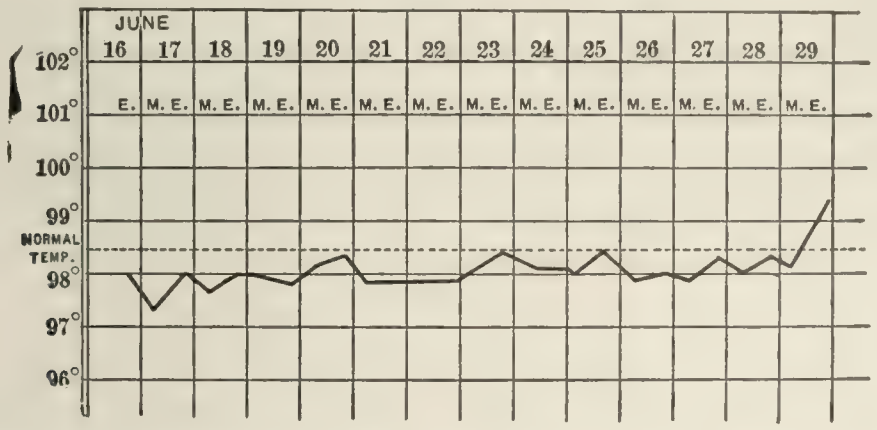


FIG. 3.—Temperature Chart of Harvard Boat Crew During Training and Immediately Before Race. (After Darling.)

taining equability of the bodily temperature notwithstanding that heat is rapidly evolved. As soon as movement ceases the heat production is checked, the body cools off rapidly and the temperature may even become subnormal. Hence, following the cessation of exercise, there is great danger of chilling unless additional clothing be donned. After extremely exhausting exertion the temperature is markedly lowered. Williams and Arnold found the temperature of all the contestants in a long-distance run at least one degree below normal, while in three it fell two degrees and in one four degrees. Prolonged training also appears to reduce the average temperature—as is shown in the accompanying temperature chart of the Harvard crew for the final fortnight of training—such reduction by many being looked upon as evidence of overtraining. The rise of temperature noted at the end of the accompanying chart occurred immediately before the race and was presumably of nervous origin.

Exercise increases the appetite, partly because of the increased demand of the muscles for food and partly on account of the increased circulation of the blood through the liver and vessels of the alimentary tract, causing a more rapid assimilation of the nutrient material ingested. After severe exercise an increased amount of carbonaceous food and of water is indicated to replenish the system in place of what has been eliminated. The increase of carbon is probably best given in the form of carbohydrates

rather than fat; and of all fluids, water is the best. As a general rule, alcohol is harmful because it benumbs and deadens the nerves and will; and, as every voluntary impulse must originate in the brain, anything that interferes with the communication between it and the muscles must lessen the promptness with which they respond and the consequent efficiency of their work. The use of a small quantity of malt liquor as a tonic during training for an athletic contest may not be harmful.

Physical training, by lessening sexuality, conduces to morality and hence promotes military efficiency through the diminution of venereal affections. The positive value of exercise in diminishing genital irritability has long been recognized.

General Results of Systematic Exercise.—The physical benefits of systematic training of young soldiers are often very surprising. As stated by Rossignol: "Young men, whom one would consider very weak for supporting the hardships incident to military service, acquire in a short time—after six months physical training—a general development of the body which one would scarcely be bold enough to hope for; and become, under the influence of exercise, strong and robust soldiers." When physical training has been properly carried out, the men are educated to act with great cohesion, rapidity and accuracy; each soldier having his individuality developed, his intelligence sharpened, his interest excited, and the general monotony of his work relieved. By such training, individual serviceability is increased, and hence also that of the whole military establishment; while, on the contrary, the diminution of future pension rolls is accomplished.

In the United States army, though but little in the way of systematic training has been done, the reports upon the results so far achieved are extremely favorable. With regard to the gymnastic exercises instituted some years since at recruiting depots, they were reported as being "severe and rapidly progressive, and giving noticeable physical development and elasticity of person, so that the individual is more quickly 'set up,' and sooner acquires good military carriage and movement."

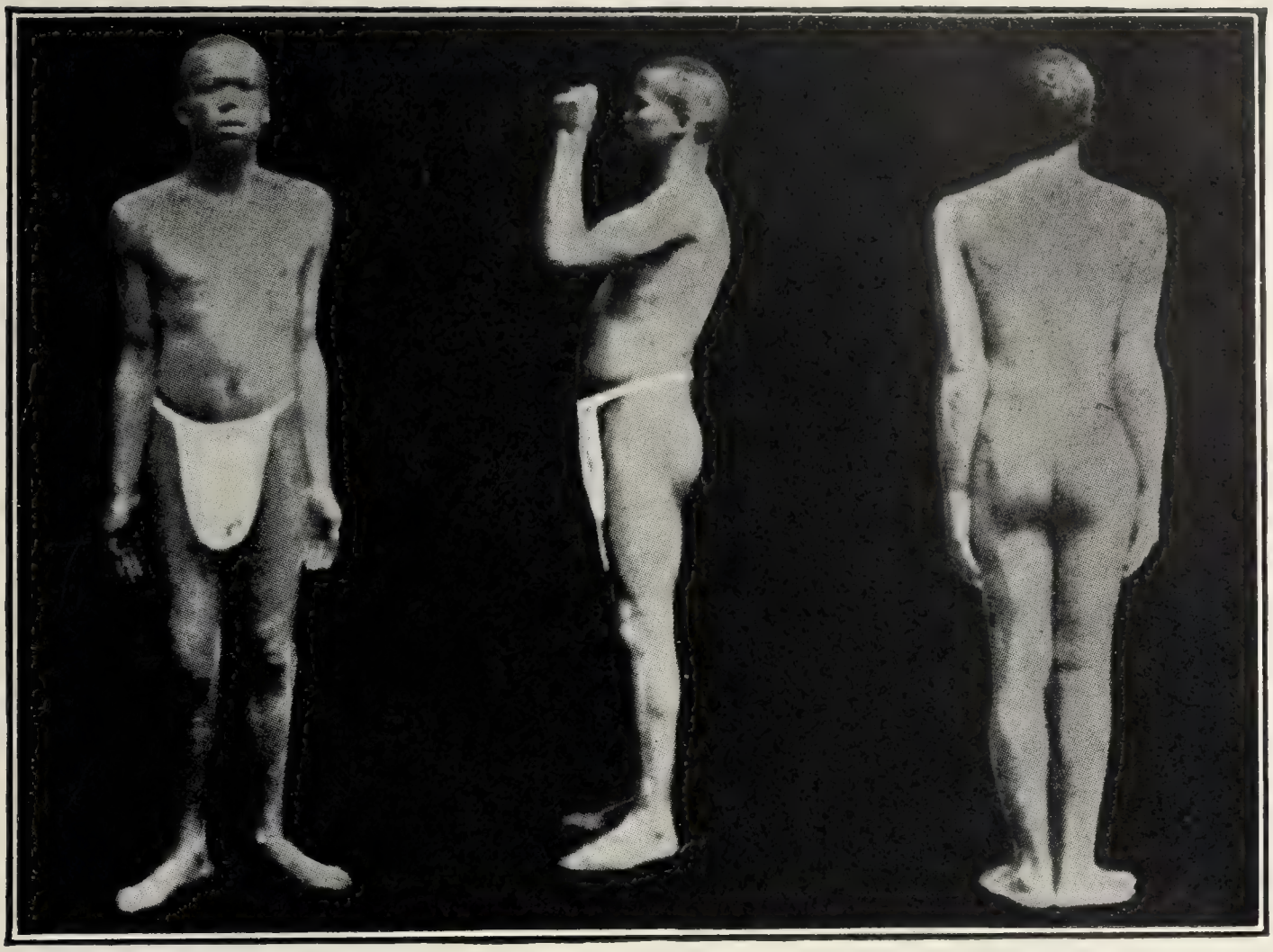
As a result of his work among recruits at Columbus Barracks, Butts obtained the following figures after a course of instruction extending over an average period of three and one-half months.

	Weight, pounds.	Expansion of chest, inches	Size when inflated, inches.	Waist, inches.	Upper arm, natural.	Upper arm bent and muscled.	Horizontal bar, times.	Parallel bar, times.	High jump in feet, standing.	High jump in feet, running.	Broad jump, standing.	Broad jump, running.
Average on arrival at depot	145.07	2.804	36.53	30.18	10.4	12.05	3.87	3.61	2.76	3.32	6.50	9.50
Average at departure from depot.	147.88	3.410	37.18	29.19	10.85	12.66	7.08	7.23	3.12	3.71	7.22	10.99
Average gains	2.81	.606	.65	.....	.44	.61	3.21	3.62	.36	.39	.72	1.49
Average losses	.....	.....	.....	.99								
Largest measurement at arrival..	179	4.5	41.5	35	12	14	9	10	3.5	4.5	9	14.5
Largest measurement at departure	184	6	42	33	12.5	14.5	12	14	3.75	4.67	10	15
Smallest measurement at arrival.	124	1.5	32	27	9	10.5	0	0	2	2.58	4	5.83
Smallest measurement at departure	126	2	33	26	9.25	11	2	1	2.33	2.83	5	7.00
Greatest gains	15	2	3	2	1	1.75	9	11	1	1.25	2.25	5.25
Greatest losses	13.5	.....	.....	4.5								

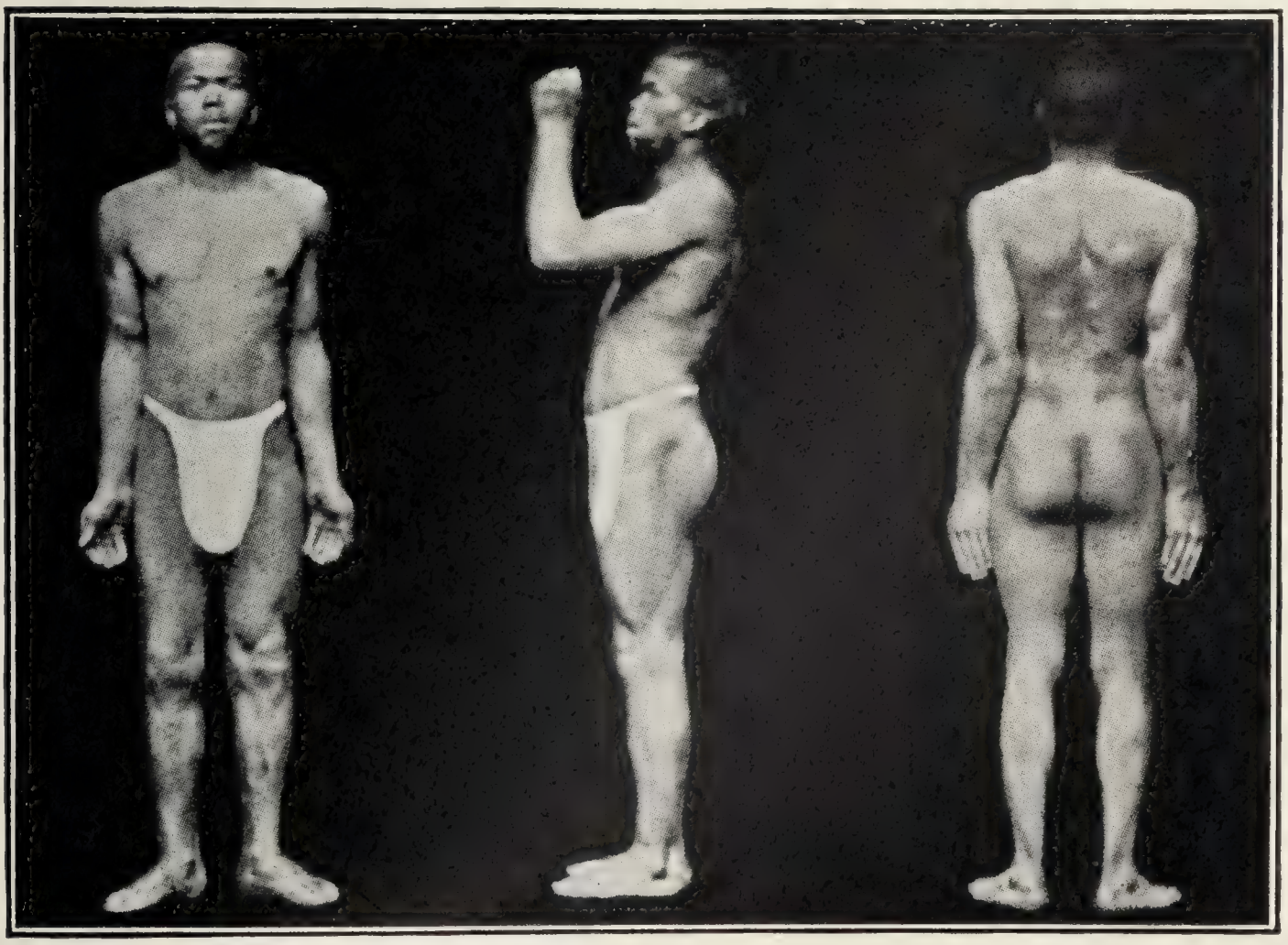
Of the results obtained on cadets at West Point, a report from a former

PLATE I.

A.



B.



IMPROVEMENT UNDER PHYSICAL TRAINING.

A. Condition at commencement of regular exercise.
B. Condition of same man at the end of six months

(After photographs by Way)

superintendent of that institution stated that "the physical tests and measurements show marked average gain at the end of the first year's work of each class, in weight, wrist measurement, forearm measurement, upper arm extended and with biceps set, chest inflated and normal, and in tests with horizontal bars, parallel bars, and broad jump."

Much valuable work has been done by Beyer, upon cadets at the United States Naval Academy, with regard to the influence of exercise upon normal growth. His investigations are particularly important in that the system of record in vogue at that institution renders possible the careful comparison of physical development when unaided by systematic exercise with that which ensued upon the establishment of a comprehensive course of physical training. Not only did he find a very marked increase in weight, strength, and lung capacity, as a result of physical training, but even the height of the cadets was much increased thereby, as shown in the following table recently officially submitted by him to the Navy Department.

HEIGHT STANDING.

	AVERAGE INCREASE IN MILLIMETERS BETWEEN THE YEARS—					
	16–17.	17–18.	18–19.	19–20.	20–21.	Total.
1. From records of 4,537 naval cadets[1], normal values	28	6	15	19	1	69
2. From records of 186 continuous individual cadets, normal values	28	20	12	7	2	69
3. From records of 243 cadets influenced by gymnastic exercise	48	26	16	12	9	111

According to the above figures the total amount of increase in height, apparently due to exercise alone, and for the entire period of four years, is 42 mm., or nearly one and three-fourths inches. This result is certainly surprising, and shows that the results of physical training are more far-reaching than had until recently been suspected. The agent which can induce an actual growth of the skeleton of nearly two inches is surely profound in its effects; and a gain in bone, as opposed to that of muscular tissue, can not subsequently be lost. It should be remembered that these cadets were trained during a period in which there is normally considerable growth, and that no such increase in height could be expected with soldiers of more mature years, in whom the bony framework has almost completed its development.

Beyer also noted that the taller the individual at the beginning of training, the greater also the increase in height, weight and strength induced by the exercise he is called upon to perform. Hence, in the selection of the recruit, he believes good height to be of prime importance. This can be accepted only within certain limits.

Many accurate data from gymnasia and colleges are now available, which are of marked value to the military sanitarian. At Harvard the following average development, based upon a class of two hundred men, was obtained by Sargent.

[1] In this number are included several hundred who left but the records of a single examination, were afterward rejected in the mental examination, and consequently never became cadets.

	Average state of development upon entering gymnasium.	Average state of growth and development after having practised in gymnasium half an hour a day four times a week for a period of six months.	Average increase in various measurements after working half an hour a day four times a week, for six months.
Age	18.3 years.		
Height	67.974 inches.	68.254 inches.	¼ inch.
Weight	134.981 pounds.	137.123 pounds.	2 pounds.
Chest (inflated)	35.067 inches.	36.829 inches.	¾ inch.
Chest (contracted)	32.29 "	33.206 "	1 "
Forearm	10.03 "	10.760 "	¾ "
Upper arm (flexed)	10.960 "	11.903 "	1 "
Shoulders (width)	15.602 "	16.260 "	¾ "
Hips	31.475 "	33.875 "	2¼ inches.
Thigh	19.612 "	20.964 "	1½ "
Calf	12.729 "	13.232 "	¾ inch.

The following table shows the effect of four hours' exercise a week for one year upon a youth of nineteen, working in the Harvard gymnasium. This was two hours' work more each week than was required of the regular class whose results are noted above.

	Age,	HEIGHT.		Weight, pounds.	Chest (inflated), inches.	Chest (contracted), inches.	Forearm, inches.	Upper arm, inches.	Shoulders, inches.	Hips, inches.	Thigh, inches.	Calf, inches.
		Feet.	Inches.									
	19	5	8	145	36½	33½	10¼	12¼	15¾	35	19¾	13½
	20	5	9	160	40	34¼	11	13¾	17	36½	22	15
Increase in one year	..	..	1	15	3½	¾	¾	1½	1¼	1½	2¼	1½

In his work among the inmates of the New York State Reformatory, Way obtained most gratifying results from physical training; the course of instruction being military marching and rifle drill supplemented by gymnastics and field athletics. Figures given by him are as follows:

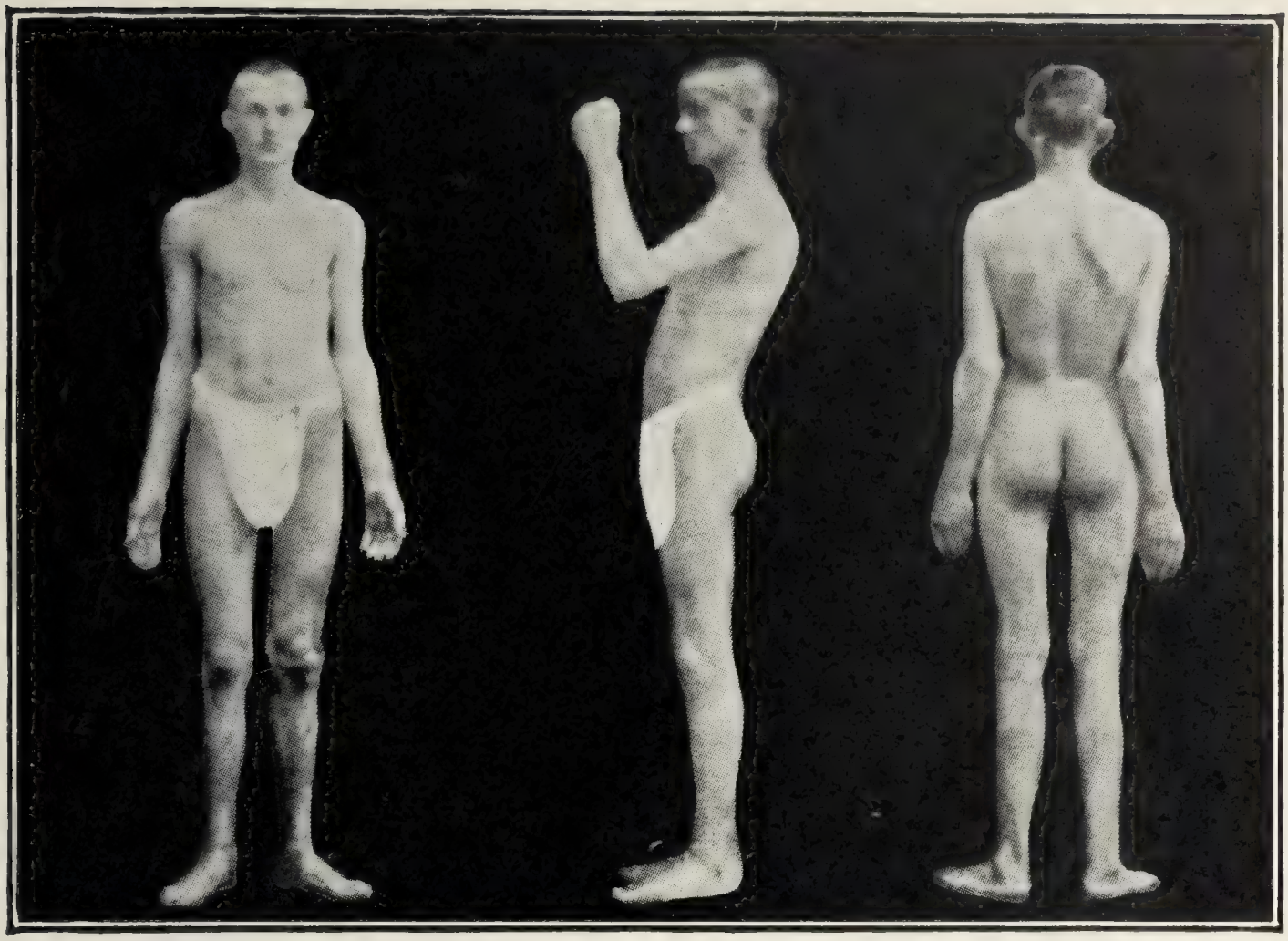
MEASUREMENTS SHOWING THE GAIN OF SIX MEN, FOUR MONTHS' COURSE.

Date.	Convict number.	Age.	Height, mm.	Weight, kgm.	Chest, mm.	Chest, full, mm.	Upper arm, mm.	Forearm, mm.	STRENGTH IN KILOGRAM OF—					
									Lungs.	Chest.	Back.	Legs.	Upper-arm.	Fore-arm.
June 10th	3,716	17	1,612	54.4	880	905	310	260	7	41	110	90	1	17
October 10th			1,620	56.3	880	930	310	265	8	50	161	203	12	31
June 12th	4,011	17	1,569	47.1	770	795	264	230	3	30	90	100	5	18
October 12th			1,575	48.2	830	872	280	248	6	38	145	176	9	22
June 16th	3,639	18	1,637	50.8	800	840	220	235	3	28	75	110	0	14
October 16th			1,646	55.2	890	955	280	261	5	32	107	134	7	29
June 17th	2,681	19	1,769	70.8	870	896	308	278	2	42	150	165	1	20
October 17th			1,775	76.9	950	986	337	289	9	42	160	280	9	27
June 12th	3,530	19	1,736	58.5	830	900	284	243	1	21	100	110	2	12
October 12th			1,743	62.8	920	956	304	261	6	50	149	260	9	33
June 17th	3,629	20	1,680	59.1	820	860	260	244	1	29	80	130	0	12
October 17th			1,690	64.9	882	930	320	280	6	40	150	232	6	22

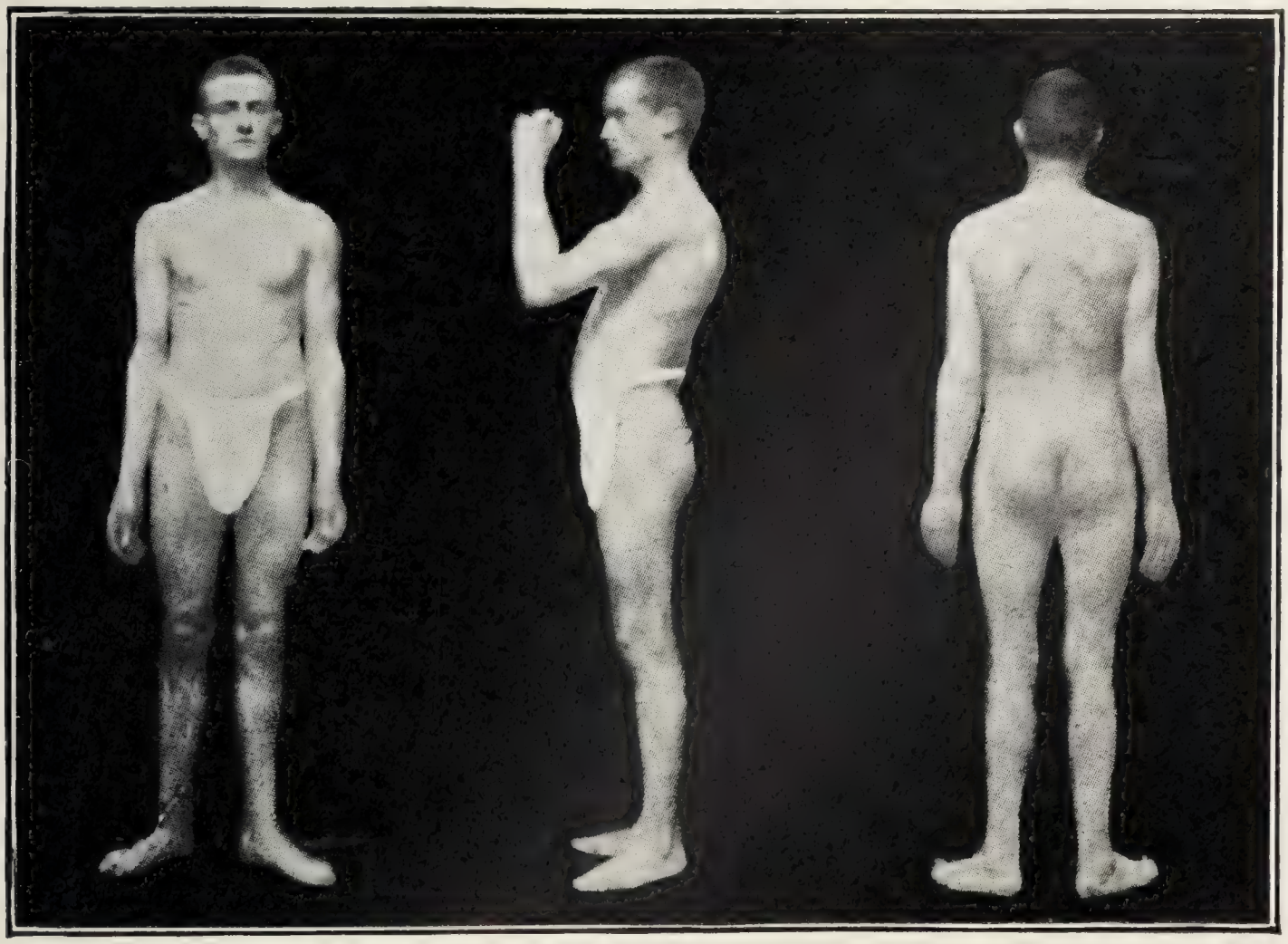
In addition to the above table the accompanying series of photographs by the same investigator show at a glance, and far more comprehensively

PLATE II.

A.



B.



IMPROVEMENT UNDER PHYSICAL TRAINING.

A. Condition at commencement of regular exercise.
B. Condition of same man at the end of six months.

(After photographs by Way.)

than could be done by figures, the pronounced changes readily induced by properly selected and controlled exercise.

According to Onslow, of the 15,504 British soldiers that completed their full course of training in 1887 in the military gymnasia of the United Kingdom, the average increase was: Weight, two and one-half pounds; chest measurement, one and one-eighth inches; forearm measurement, one-half inch; upper arm measurement, three-fourths inch—thus accomplishing in chest girth in three months as much as had been gradually brought about, prior to the introduction of physical training, during the first five years of service with the colors.

At one time twelve non-commissioned officers, selected from all branches of the British service, were sent to Maclaren to qualify as instructors in military gymnastics. These men ranged between nineteen and twenty-nine years of age, between sixty-five and seventy-two inches in height, and between one hundred and twenty-eight and one hundred and seventy-four pounds in weight. Of the results of the training of these men he says: "The muscular additions to the arms and shoulders and the expansion of the chest were so great as to have absolutely a ludicrous and embarrassing result; for, before the fourth month, several of the men could not get into their uniforms, jackets, and tunics without assistance, and when they had got them on, they could not get them to meet down the middle by a hand's breadth. In a month more they could not get into them at all; and new clothing had to be procured; pending the arrival of which the men had to go to and from the gymnasium in their great-coats. One of these men gained five inches in actual girth of chest." And Maclaren well adds: "Now who shall tell the value of these five inches of chest, five inches of additional space for the heart and lungs to work in?" All these men increased decidedly in weight—the smallest gain being five pounds, while the average was ten pounds. One man gained sixteen pounds in less than four months; and it is unlikely that any of this increase was due to fat. Every man's chest enlarged decidedly; the smallest gain during the four months was one inch, the average two and seven-eighths, and the largest—in a man twenty-eight years of age—five inches. And he adds: "But the greatest of all changes, a change which I could not record, was the change in bodily activity, dexterity, presence of mind, and endurance of fatigue; a change a hundred-fold more impressive than anything the tape measure and weighing-chair can reveal."

Again, from the Royal Military Academy at Woolwich, Maclaren took twenty-one cadets having an average age of eighteen years, and in the brief period of four and one-half months obtained an average advance of one and three-fourths pounds in weight, two and one-half inches in chest, and one inch on the upper arm; while one slender youth of nineteen gained eight pounds in weight, and five and one-fourth inches around the chest. To gain five inches of chest girth and nearly that amount of lung, heart, and stomach room, with a consequent greater capacity for all the vital organs, is a matter, to any man, of almost immeasurable value.

Rigal noted that chest capacity might increase even if the circumference diminished, a fact which he believed to be due to the absorption of fat. He found that among the weaker men at enlistment the greatest increase in weight ultimately resulted. Fetzer found that in the French

army the chest capacity of 292 recruits had increased an average of half a liter after ten months of training. In a study of the Sixteenth Army Corps, Frilley noted that in 5,999 recruits there was an average gain of 5 millimeters in height, of 1.058 kilograms in weight, and of 12 millimeters in chest measure. Mandoul, experimenting with two hundred and thirty men of the Twenty-second Infantry and a number of young men of the Third Hussars, arrived at analogous results, as follows: Increased height, after serving one year, 6 millimeters; increased chest measure, 15 millimeters; increased weight, 2 kilograms.

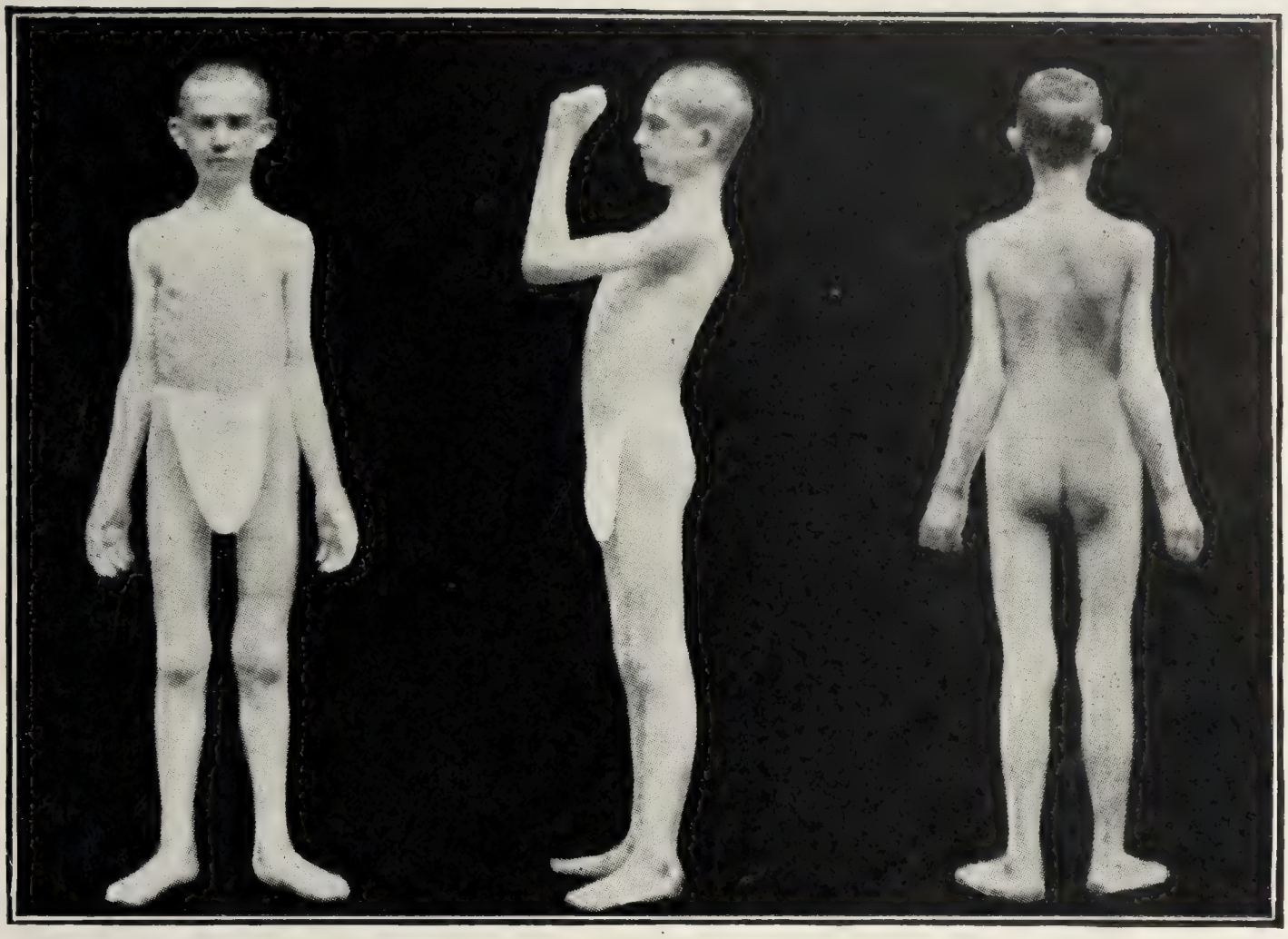
In analyzing their results at the French military school of physical training at Joinville-sur-Pont, Chassagne and Dally found that 76 per cent of 401 men examined showed an increase in chest measure of 20 to 30 millimeters. In the same number the circumference of the arm was increased in 332, forearm in 250, and thigh in 258. The dynamometric force of the two hands increased in 344 cases (86 per cent.), decreased in 42 and remained stationary in 15. In the great majority the increase in strength was from 25 to 30 kilograms. As a result of physical training they found that "young men develop in chest-girth and muscle, the weak in strength, the awkward in agility, and the timid in confidence."

In the military service the obvious results of exercise include development of the muscular system, increase of the respiratory capacity, stimulation of the nerves, and diminution of adipose deposits. Apart from these well recognized results, however, it should not be forgotten that the increased girth of the extremities is not the only indication of their added strength, since it does not take into the account their firmness and contractile power gained even before the growth began. "The quickened sympathy between brain and muscle is not readily demonstrable, nor are suppleness, agility, and self-confidence to be represented in figures." Although the effects of exercise are particularly notable in the former artisan or city-bred recruit, any man who has received judicious physical training as a soldier can readily be distinguished from his fellows who remain in civil life. He has a springy step, an erect and easy carriage, his abdomen is retracted, his head is mobile but well raised, his chest is expanded and his shoulders are squared.

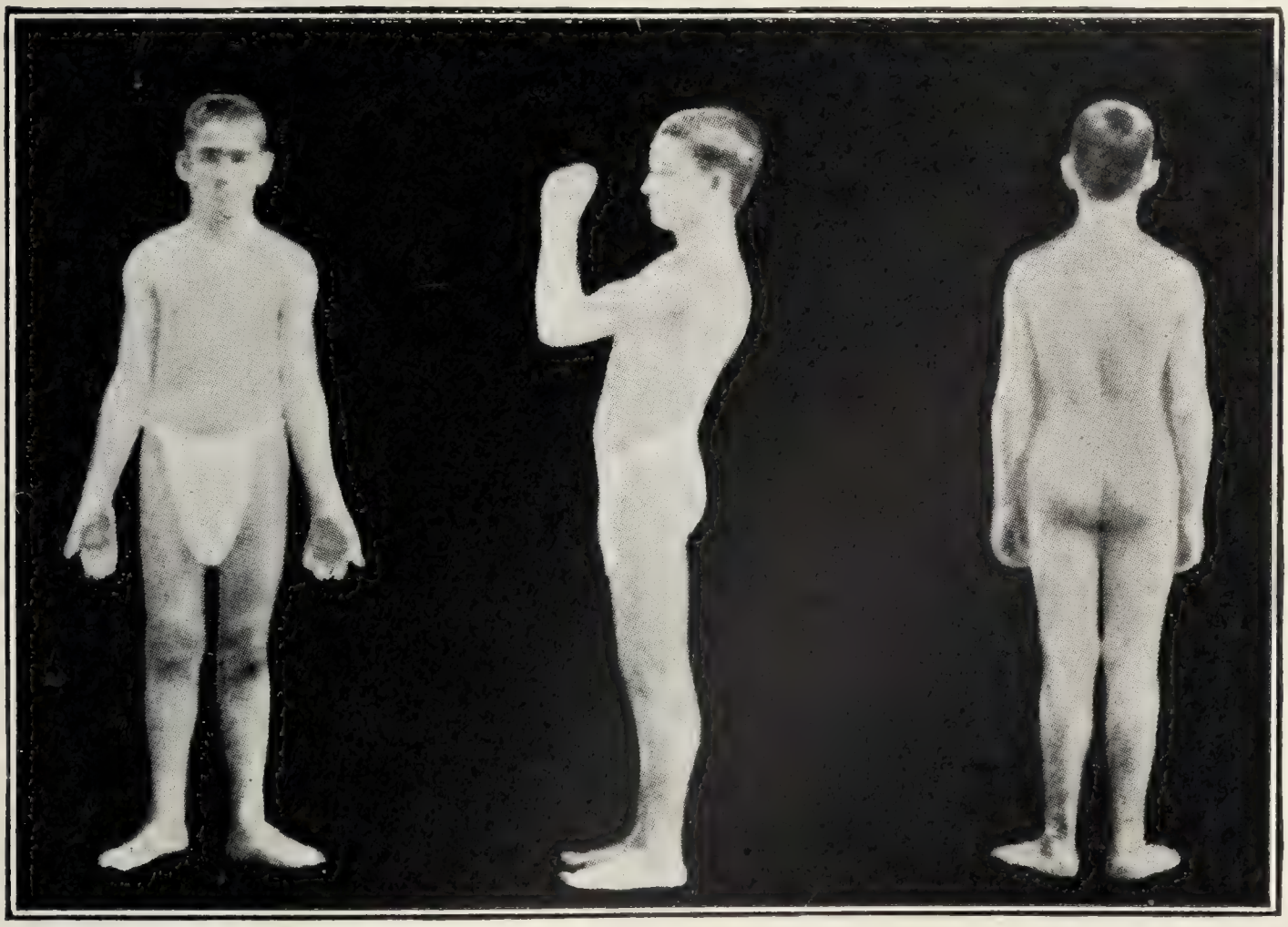
Exercise as Influencing the Occurrence of Disease.—With regard to the part directly played by physical training in the prevention of disease but little investigation has been done, and sufficiently elaborate statistics are lacking. Hitchcock, however, in his observation of students at Amherst College, believed that systematic exercise redounded to the general health in that institution, the average sickness among the seniors being about half that constantly prevailing among the freshmen; and similar conclusions have been drawn by Sargent as a result of his work among the students of Harvard University. Of the correctness of these conclusions common experience is witness. A certain amount of muscular exercise has long been recognized as being highly beneficial in health, and as actually necessary to the proper performance of organic function. Life must be considered as essentially organization in action. Physical training undoubtedly promotes health as well as strength by quickening the circulation and increasing the respiratory powers. Systematic exercise aids in resisting disease, since, as a result of muscular action, healthy and

PLATE III.

A.



B.



IMPROVEMENT UNDER PHYSICAL TRAINING.

A. Condition of youth 16 years of age, immediately prior to entering upon a systematized course of exercise.

B. Physical condition of same youth at the end of three months.

(After photographs by Way.)

active tissues take the place of weak and sluggish ones, glandular and organic functions are stimulated and waste material is eliminated. Its directly favorable influence in the maintenance of health and the prevention of disease cannot be gainsaid. "A fine physique once gained is never wholly lost. He who has satisfied his physical obligations, whose credit with nature is good, is not visited by her heavy penalties for subsequent shortcomings."

Government of Exercise.—Physical training should be begun and increased with moderation, and is not to be continued after great fatigue is manifest. Too violent exercise under any circumstances does more harm than good. The movements to be employed should be from time to time prescribed, and their execution systematized, in order to avoid injury arising from an unwisely selected and unintelligently executed exercise, or the development to an abnormal degree of any particular portion of the body.

Agility in the soldier is rather to be desired than great strength, and most recruits possess considerable muscular development and little activity. Hence the efforts of the instructor should be largely directed toward suppling the joints, and educating the men properly to use the strength they already possess. This is best done by light but continued exercise, for the trained use of an organ renders it more effective in the performance of its functions. While securing the modicum of agility and strength in the soldier the true aim of physical drill is to develop and keep in good health the whole body.

To ensure the greatest advantage from physical training there should be a record book kept of each company, and an examination made each month by a medical officer with a view of noting the progress made, discovering the neglected parts which need strengthening and instituting such course in each individual case as will tend to gradually develop and perfect the entire system to a sound and healthy condition. Should a man have difficulty in executing an exercise, readily accomplished by his comrades, he should be carefully examined to ascertain if any physical cause can be found to account for it, especially as regards his heart.

The best time for exercise is midway between meals, preferably in the forenoon from two to three hours after eating. Physical training in the early morning before breakfast is wrong in every respect, and may then result in as much harm as it is, when properly timed, capable of doing good. Men just risen from bed are wanting in nervous energy, have relaxed muscles, and are not physically prepared to undergo fatiguing exercise. If such a plan be long maintained a noticeable rise in the sick rate will surely follow, particularly in a malarious country. Early morning setting-up drill is a not infrequent fad of commanding officers which military sanitarians will do well to discourage.

If exercise be taken too soon before meals, either the stomach, by calling the blood from the exhausted muscles, will prevent their proper repair and rest; or the muscles, calling the blood from the stomach, will prevent the proper supply of gastric juice. If exercise be taken too soon after eating, it is apt to prevent the flow of blood to the stomach and the formation of gastric juice; or by forcing the contents of the stomach into the intestines before gastric digestion is completed, and before the food

has reached a condition in which the intestines can make use of it, to cause intestinal irritation and indigestion.

As to duration, in beginning the physical training of the recruit not more than fifteen minutes' gymnastic or setting-up exercise should be required at any one time. Later the men can receive with advantage one hour's physical training daily, preferably half in the morning and half in the afternoon; this being continued for five days during each week. The duration and severity of the exercise should be increased gradually, and in beginning or ending the daily period of instruction the lighter movements should be chosen.

The exercise should be suspended whenever the men show signs of muscular weariness or of being out of breath. The pulse also is to be observed when necessary. If it become irregular or its rate rise to 130 or 140, a rest should be required. It should not be forgotten that severe sudden effort may rupture a muscle, tendon, or even bone of attachment, and that hernia is liable to be caused by too violent gymnastic exercise.

If drills or gymnastics must take place indoors, the room should be large and well ventilated; but as a general rule men should be exercised in the open air rather than in buildings. In rainy or very hot weather these drills are advantageously carried on in sheds or porches.

During rests and after periods of work the men should not be chilled by exposure to currents of cold air. Whenever possible, the exercise should be followed by a cool shower bath for the maintenance of comfort and cleanliness. If this is not obtainable, the men, if heated, may rub themselves dry with towels before going into the cold air outside; and, after exercising, additional clothing should under all circumstances be donned to prevent chilling. Thirst may be satisfied by drinking cautiously—if necessary at frequent intervals.

The amount of energy to be expended should be intelligently controlled. The usual estimate of the minimum amount of daily muscular exercise required to keep a man in healthful condition is that it should be about 150 foot-tons; or equal to a walk of about nine miles, without weight-carrying, on level ground. That this is no great amount will be readily appreciated if it is considered into how many apparently unimportant movements the daily expenditure of energy is divided. For the accomplishment of the physical development of the soldier a greater amount of exercise is required, and when this is properly distributed over several groups of muscles, a daily average of 300 to 350 foot-tons as the total amount of work to be done is probably not too large an estimate.

Without adequate preparation even the strongest man is unfit for great exertion. A young recruit cannot keep pace with a full grown and completely trained man in the ranks, mainly because his heart and blood vessels are not fully developed nor specially trained. Failure arises usually from attempting too much at the outset; and with excessive work at the beginning or with a sudden increase, as in forced marches, such youths rapidly break down.

The taking of exercise merely for its own sake soon becomes to most men a task for which they grudge the time. Exercise should always be recreation. Unless it gives pleasure and relaxes mental tension at the

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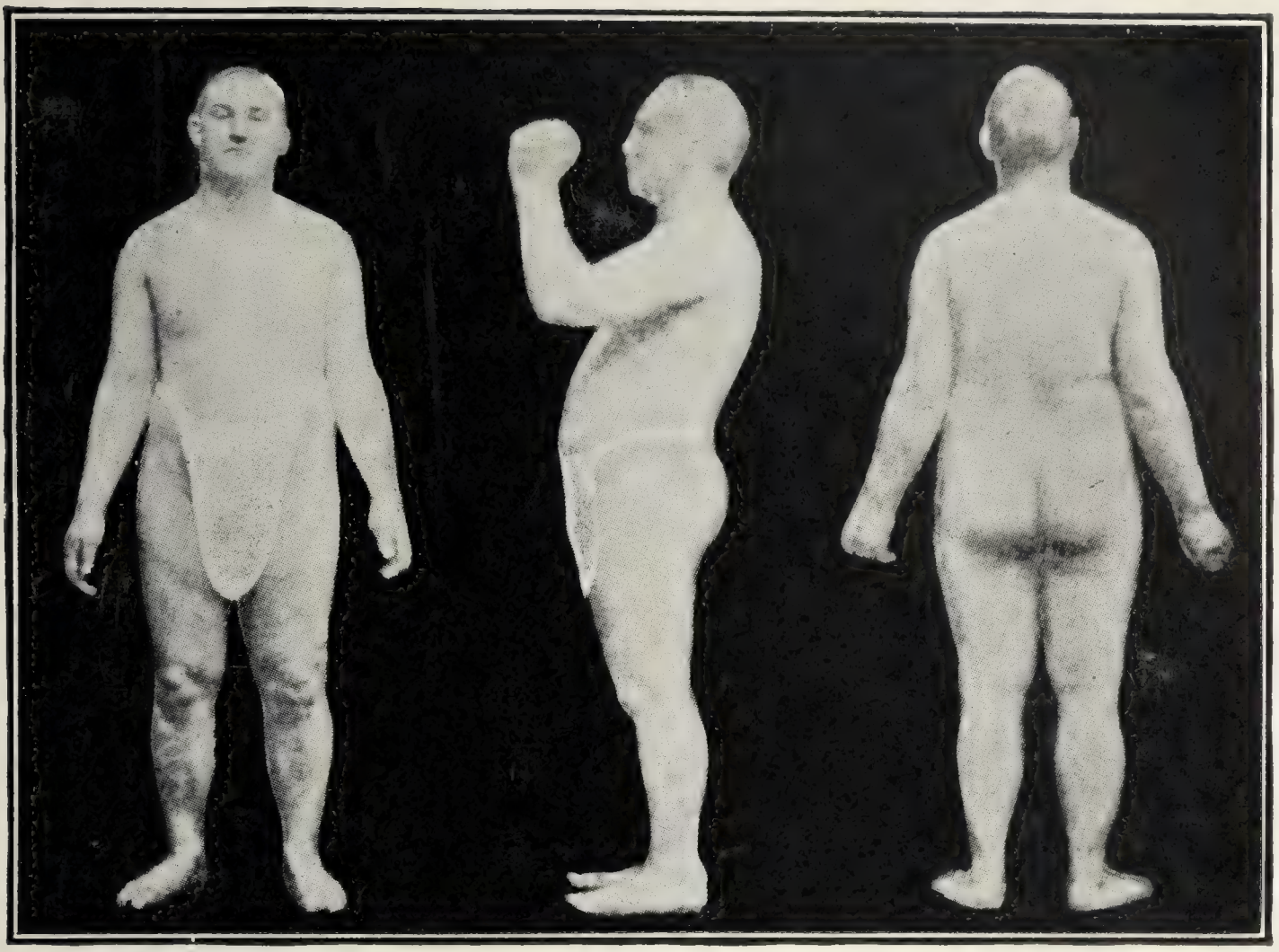
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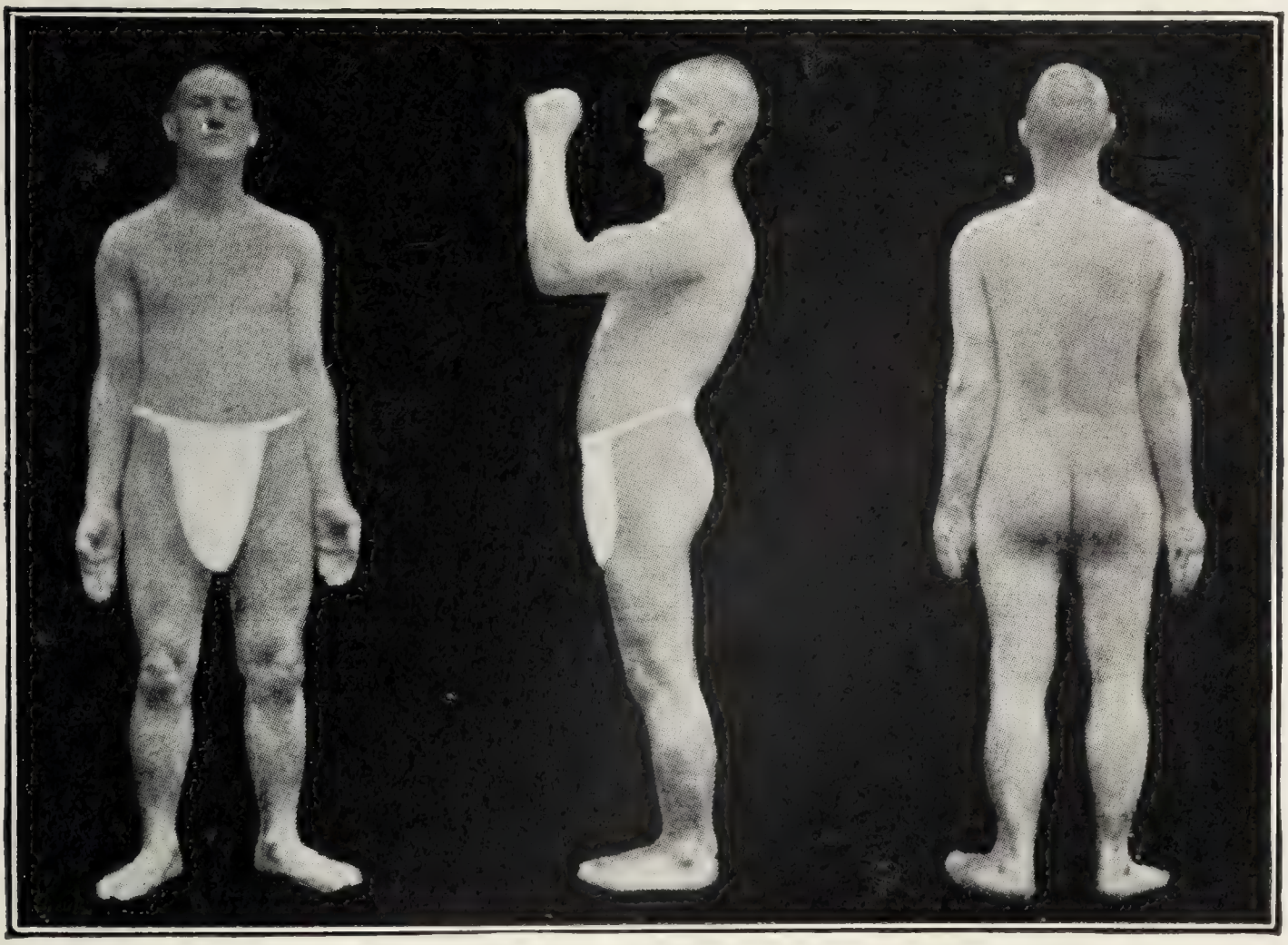
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PLATE IV.

A.



B.



IMPROVEMENT UNDER PHYSICAL TRAINING.

A. Condition at commencement of regular exercise.
B. Condition of same man at the end of six months.

(After photographs by Way.)

same time that it occupies the limbs exercise becomes labor—an added strain and not a diversion. The movements employed should be subjected to wide variation. Those giving general development as well as those educating special groups of muscles should be employed; but such constant repetition as makes the work mechanical and tiresome should be avoided. When accompanied with music and perhaps varied by simple changes of formation, the object desired will be obtained without undue fatigue. Except in the purely military exercises, such as the setting-up and bayonet drills, the men should not be held under the strictest restraint and military discipline; and too great severity during general gymnastics should not be used in repressing the signs of interest and pleasure which may be excited by competition and exercise.

Purely mechanical movements, by their monotony, will become wearisome and lose their efficiency. Hence the best exercises for the soldier are those in which he does not simply obey a command mechanically, but employs his mind and body under the influence of present necessity—fencing, wrestling, and boxing being of particular advantage. The best results of exertion are often obtained by directing the mind and efforts toward some other object; and thus purely gymnastic exercises can scarcely be as satisfactory as out-of-door games and athletic contests. The instructor should render the work as agreeable as possible, and in taking due precautions against injury he should avoid exciting apprehension. Muscle and mind must be gradually educated, and both undue tension and ill-regulated effort serve to retard development. It has long been noted that physical training in general, but particularly athletic sports, exerts a marked effect no the morale of troops as well as on their physical condition, rendering men more interested in their work and contented with their lot. This has its influence in diminishing the evils of desertion and drunkenness.

Division of Exercise.—Pilcher divides the physical training of the recruit into two parts. The first builds up to symmetry and muscular harmony men whose physique is below standard, imparts that ready command over the muscular system which follows thorough training, and contributes to the quickness of mental apprehension only to be derived from exercising in response to frequently varied commands. The time during which the recruit should remain in this class is very variable, depending on the amount of deviation from the normal type and the readiness of response to treatment. The second class of training is purely conservative and aims at the maintenance of a well-balanced bodily condition. After this has once been secured, very little effort suffices to overcome the retrograde tendency characteristic of all forms of life when stimulated to a higher grade; but a certain degree of training must be constantly maintained, and the exercises, though not arduous, should be numerous and varied. During the first period the recruit should be held under medical supervision to ensure proper direction of the training and prevent excess of application—but when he passes into the second class the medical inspection may be much less minute, though never to be entirely withdrawn.

Training.—In the technical sense, to "train" is to lead the most healthful life possible while by appropriate exercise the body is prepared for some supreme effort. Diet is plain but otherwise unrestricted, but alcohol and tobacco are to be tabooed except on rare occasions. From eight to ten

hours' sleep should be prescribed. The methods of training employed of course vary according to the results desired. Under any circumstances it should be slow and progressive, nothing beyond the power of endurance being required and the heart and lungs being gradually adapted to the unusual labor they are called upon to perform. Training will not be employed in the military service save in the case of the few individuals who enter into department or other athletic competitions.

Exhaustion.—If the physical training of the soldier be not properly governed the condition known as exhaustion soon supervenes; this being a guard against over-exertion as hunger is against inanition. Fatigue may be due to lack of sufficient contractile material in the muscles to do the work required or to the exhaustion of nerve force and the weakening of the motor impulses from the brain, but is undoubtedly largely determined by the accumulation of carbon dioxide and other waste products in the organism. In any case the sense of fatigue cannot be taken as the measure of actual muscular exhaustion, since under the influence of fear or excitement men frequently accomplish feats which, without such stimulus, they have previously declared themselves unable to perform. The will, in fact, rarely if ever calls forth the greatest contractions of which the muscles are capable. In general, the symptoms of fatigue are similar to those of fever. Muscles undergoing frequent contraction become painful, and if fatigue be great the heart becomes weak, the arterial tension falling from impaired cardiac action. Signs of exhaustion naturally occur first in the weak, young or illy developed; and hence, as the personal equation varies so greatly, it is a difficult matter to determine other than by actual experience the maximum amount of exercise which could be taken by a given individual. When a large number of men are being exercised together the capacity of the weaker rather than the stronger must be considered as the standard. Drill must be within the powers of endurance, and the young soldier, usually keeping up too long from pride, should be encouraged to fall out of ranks when distressed and remain quiet until normal circulation and respiration are resumed. It is well, at first, to stop short of actual fatigue; and hence recruits should be drilled with moderation, particular care in this respect being given the younger men.

The results of exercise, beneficial if the task be moderate, are quite different if it be carried on to the point of exhaustion. Rigal noted among the Twelfth Chasseurs that following severe manœuvres in a mountainous country the weight diminished, as did also the chest measure. He observed many cases of exhaustion, and noted that the men admitted to hospital had lost on an average six kilograms of their weight. Excessive exertion, especially when combined with exposure to cold, is a fruitful source of nervous disease, and during winter campaigns nervous weakness, myelitis and tabes are common maladies of soldiers. In hot countries excessive fatigue plays a most important, if not, indeed, essential part in the causation of sunstroke. Exhaustion, especially when frequently repeated, renders the soldier an easy prey to disease of an infectious nature. Léques noted that the French soldiers of the Alpine districts are particularly liable to typhoid fever, a fact which he attributed largely to the exhausting character of the duties required of these troops. All foreign military sanitarians appear to agree with Czernicki and Coustan that the increased sick rate from typhoid

fever among troops during manœuvres is largely, though indirectly, dependent on physical exhaustion.

Overtraining.—The common symptoms of this condition are well known. They are, in brief, a loss of strength and endurance, so that a man previously strong becomes incapable of prolonged effort. This may be accompanied by a general nervous restlessness, listlessness, a loss of weight, insomnia, and various digestive disturbances, such as anorexia and diarrhœa. These symptoms should not be confounded with the temporary collapse which is occasionally seen after a severe exertion, and which is more apt to be due to undertraining than to overwork. The condition known as overtraining may often be seen in soldiers engaged in prolonged campaign and hard marching, particularly with poor food and frequent conflict with the enemy.

The real condition at the bottom of overtraining is still somewhat obscure, but in the light of recent inquiry certain possibilities are suggested by Darling as factors which may have much to do with its causation. The first and most obvious one is the condition of the heart. A great increase in size and strength is demanded of this organ, and it may easily happen that it is called upon for more work than it is able to do, and that instead of establishing a compensatory hypertrophy it becomes dilated and weakened. A "broken-winded" athlete or soldier is probably one with a dilated, flabby heart. The second possible factor is the condition of nutrition. This is more difficult of demonstration than the first. The nutrition may be disturbed in two ways, either by an improper diet, in which the nutritive elements are not apportioned to the needs of the body, or by disturbed digestion, as a result of which the food taken into the body is not utilized. That both of these contingencies may occur has been sufficiently demonstrated. Further, as already stated, the influence of exhaustion of reserve fuel, in the form of fat and glycogen, in the production of overtraining, is undoubtedly of great importance. The third factor may be simple overwork. This is not so likely as the two preceding; for, when properly nourished, the capacity for work on the part of healthy young men is certainly much greater than that demanded in training. The peculiarity of severe training, however, is its concentration. It may be that the excessive work accomplished in a brief space of time exhausts the muscles so that they do not recuperate before being called upon for a repetition of the work—that there is, so to speak, an accumulation of fatigue, and that this constitutes overtraining. The fourth factor which suggests itself is a nervous one, and this, while more intangible than the others, is unquestionably important. In the present state of our knowledge it can be only surmised, not proved. It is well known that there is a nervous fatigue entirely distinct from muscular fatigue and resulting from prolonged anxiety, from monotony of work, and from numerous other causes. It may be that anxiety leads to a condition of nervous exhaustion, and that this nervous exhaustion contributes to overtraining.

No one of these factors will account for all cases of overtraining and probably more than one cause must be admitted. At any rate it is safe to suggest certain points which should be borne in mind in laying out any course of training. They are (1) not to throw too much work upon the muscles, and especially upon the heart, until they are strengthened by pre-

liminary work; (2) to watch the nutrition carefully, and (3) to avoid nervous fatigue by providing a certain variety of exercise, and by not confining the attention too closely to the results to be attained.

Proper Physical Proportions.—While the physically perfect man is a figment of the imagination, the following comparative measurements, as given by Blaikie, show the ideal proportionate development which physical training endeavors to produce in soldiers.

(1) The neck, muscled arms and legs around the calves should measure the same.

(2) The upper arms relaxed should measure two to two and one-half inches more than the forearm.

(3) The circumference of the shoulder should be about four inches more than that of the neck.

(4) The circumference of the shoulders should be about four inches more than that of the muscular chest inflated.

(5) The difference between the expanded and unexpanded respiratory chest should be about four inches.

(6) The muscular chest expanded should be eight to ten inches larger than the smallest natural waist.

(7) The chest width should be about two and one-half inches more than the chest depth.

(8) The largest hip measurement should be four to five inches larger than the smallest natural waist measurement.

(9) The thigh should measure six or seven inches more than the calf.

Development of Special Parts.—As summarized by Maclaren, "where the activity is, there will be the development." Bearing this fact in mind, the determination of muscular growth becomes at once simplified and readily accomplished. While the exercises which bring into action any given set of muscles are very numerous, a few may here be given, which, on account of their simplicity and the fact that either inexpensive apparatus, or none at all, is required for their accomplishment, are practically adapted to the needs of the military service. A larger variety of movements, essential for the physical culture of the weak, dwarfed and undeveloped of civil life, are scarcely to be required in the case of the recruit, himself already free from blemish and selected under standards which ensure his general physical superiority to the class from which he is derived. The exercises may be conveniently arranged as follows:

1. To develop the calf of the leg (*a*) the seventeenth exercise of the setting-up drill is unsurpassed. To this may be added, (*b*) running on the toes, (*c*) jumping—both high and flat—and (*d*) hopping. The fourteenth and fifteenth exercises of the setting-up drill are also valuable.

2. To increase the size and power of the shin muscles (*a*) the thirteenth exercise of the setting-up drill is probably the best. This exercise may be supplemented by (*b*) balancing on one foot, holding the other clear of the floor and then drawing it up as nearly as possible to the front of its own ankle. (*c*) Walking on the heels serves the same purpose.

3. To develop the anterior muscles of the thigh (*a*) the fourteenth exercise of the setting-up drill may be employed. A more severe tax is (*b*) by extending one foot either front or rear and then stooping down wholly on the other foot. (*c*) Jumping, either high or flat, is admirable

for the thighs; as are also (*d*) fast walking and (*e*) running. (*f*) Hopping, excellent for the calves, is hardly less so for the front of the thighs. (*g*) Cycling and (*h*) horse exercise also enlarge these important muscles.

4. To develop the thigh posteriorly (*a*) the eleventh setting-up exercise may be employed. (*b*) Hill climbing is excellent; while (*c*) running with the foot thrown high behind is best of all.

5. To add strength to the loins (*a*) the eighth, (*b*) the eleventh and (*c*) the twelfth setting-up exercises may be employed. (*d*) Bending down, and touching the floor with light dumb-bells—the knees being kept rigid—is probably the best exercise for these muscles.

6. The abdominal muscles are well brought into action by (*a*) the eighth setting-up exercise; (*b*) the eleventh and (*c*) twelfth exercises having a less powerful influence in this respect. The best method consists (*d*) in lying on the back and drawing the straightened legs upward until the vertical position is reached and then lowering them until horizontal. Another method consists (*e*) in taking the same recumbent position, keeping the legs down and drawing up the body until sitting erect. (*f*) Running implies great activity of these muscles.

7. To strengthen the sides of the waist (*a*) the ninth setting-up exercise may be employed. A better method than this, however, consists (*b*) in extending one hand vertically above the head, while the other is brought down against the thigh, the arms rapidly alternating in position.

8. To develop the trunk above the waist the (*a*) first, (*b*) second, (*c*) third, (*d*) fourth, (*e*) sixth and (*f*) seventh setting-up exercises are all excellent and each should be briefly employed in its turn. For more severe exercise these motions may be carried out with light dumb-bells.

9. To enlarge and strengthen the front of the chest (*a*) the exercises given below for the development of the biceps and triceps will be of advantage. Of particular value in this connection is (*b*) the second setting-up exercise. (*c*) Using dumb-bells with the arms extended at right angles to the body, and moving them up or down for a foot or so, is one of the best exercises for the upper portion of the pectoral muscles.

10. In filling out the shoulders and upper back (*a*) the arms, hanging at the sides, may be carried backward and upward, keeping the arms parallel and straight at the elbows. They are held in position a moment and then allowed to drop slowly back to the sides. Light weights or dumb-bells may be advantageously used in the execution of this movement. (*b*) The second and (*c*) the fourth setting-up exercises are excellent for the development of this region.

11. To bring up the muscles of the front and side of the shoulder (*a*) the holding of weights at arms' length is excellent. The weight of the hands, as in boxing, or the sabre or foil, falls directly at this point. (*b*) With the elbows straightened and the arms held parallel the bells are raised vertically over the head and then returned to the original position. (*c*) Holding the bells at the side, they are raised behind as far as possible and then lowered as before.

12. To develop the neck (*a*) carry the head forward and back, and also move it laterally. (*b*) Resting on the head and heels—the so-called "wrestler's bridge"—is an admirable exercise for this purpose.

13. The triceps muscle is brought into action in (*a*) the first portion of

the seventh setting-up exercise. A better exercise, however, is (*b*) to push up light dumb-bells vertically above the head. A more severe test is (*c*) to stand facing a wall and about two feet from it. The hands are placed on the wall about three feet apart; the body is allowed to fall slowly in until the chest nearly touchès the wall and is then pushed back until the erect position is again assumed.

14. To enlarge the biceps (*a*) the use of light dumb-bells or other weights is desirable. Starting with these held at the sides, they should be raised slowly and steadily in front until they nearly touch the shoulder. The neck is held well back and the bells are lowered slowly to the sides. (*b*) Picking up weights or (*c*) holding weights at arms' length are valuable exercises in this connection.

15. For the development of the forearm (*a*) the fifth setting-up exercise is admirable. It should, however, be assisted (*b*) by flexion and extension of the wrist and (*c*) by the motions of pronation and supination, preferably with light weights.

16. The development of the muscles of the hand is provided for (*a*) in the fifth setting-up exercise. For improving the grasp of the hand (*b*) the simple squeezing of a rubber ball, a wad of any elastic material, or even paper, will soon tell.

17. For the development of the lungs themselves deep breathing is essential; and, as this is induced by any active exertion, marked improvement will follow brisk general exercise irrespective of special physical training. Excellent lateral chest expansion follows the use of the first and fifth setting-up exercises. To deepen the chest employ the eleventh setting-up exercise, or (*c*) hold the arms horizontally in front and slowly raise them to the vertical position. The head should be held high, preferably even back of the vertical line.

General Plan for Physical Development.—Maclaren suggests the following system of gymnastics as fitted to afford harmonious development. First: an introductory course of posturing and light exercise with dumb-bells and bar-bells. Second: leaping the horizontal bar, vaulting bar and horse. Third: parallel bars, swinging rings, ladder, horizontal bar and plank. Fourth: climbing the pole—fixed, slanting, turning—ropes, rosary and mast.

A schedule for the varied instruction of a company where but little gymnastic apparatus is available, or only that which could be put up at any post, as given by Butts, is as follows:

Lesson.	Ten minutes drill.	Ten minutes drill.	Ten minutes drill.
1....	Rifle drill.....	Running and walking	Calisthenics.
2....	Dumb-bells.....	Hurdling and sprinting	Bar-bell.
3....	Calisthenics.....	Wall scaling	Medicine ball.
4....	Rifle drill	Long and high jumping	Climbing ropes, planks, etc.
5....	Rifle drill	Running and passing obstacles.	Horizontal beams.
6....	Calisthenics.....	Hurdling and sprinting	Bar-bells.
7....	Indian clubs	Wall scaling	Medicine ball.
8....	Dumb-bells	Climbing ropes, planks, etc....	Cock-fight.
9....	Rifle drill.....	Long and high jumping	Carrying wounded.
10....	Calisthenics	Horizontal beams	Wall scaling.

To the exercises as prescribed above by Butts may be advantageously

added wrestling (the most generally valuable of all exercises), boxing, fencing, and broad-sword exercise, bayonet and sabre drill. Where such apparatus is available, the use of the chest weights and rowing machine will be found of the greatest advantage.

At least once a week during the season field sports should be indulged in; such general exercises as hurdling and running at the various distances being particularly encouraged. Where prizes are to be given they should not be awarded for excellence in any one sport or event, but should be reserved for the best all-around athletes—the men who excel under any conditions which may be imposed upon them. It should always be remembered that the athletic specialist is of but little advantage in the military service.

For the use of the trained soldier there should be, in every garrison, walls for practice in the escalade by mutual support, hurdles and ditches to leap, banks to jump off, and bars to vault. These exercises, at first practised without the equipment, should ultimately be done in heavy marching order. The changes should be rung on these exercises and they should be performed at least two hours weekly.

Whatever be the course of instruction employed, a carefully prepared scheme—possessing both the elements of pastime and instruction—should always be developed. Such a scheme should not, however, be of too military a character; and set movement should be largely avoided, as being too mechanical and monotonous to be attractive to the soldier. Under any circumstances the men should be divided into squads according to proficiency, so that such exercises may be selected as will give the best results. One set may need strength, while another shows the awkward powers of the laborer and requires agility.

Hartwell thus enumerates the four conditions which physical education must meet in order to be successful:

1. It must have a direct and large effect upon the health. It must build up vitality. The large muscular groups of the body, the muscles of the back, the waist, the chest, the thighs, must be made to contract with vigor a large number of times. It is through such vigorous contraction of these large groups that the heart is strengthened, the lungs are brought to their best condition of development, and the digestive system is stimulated to more perfect action. Upon the satisfactory working of these three systems health and vigor largely depend.

2. There should be that training which will confer skill in handling the body. The hands, arms, and body should be trained to act with skill and activity. A high degree of co-ordination should be rendered easily possible. The muscles of the trunk and the nerve centres governing them must be brought into that condition of discipline which will enable them to act with the greatest readiness and freedom.

3. There should be secured that control of the body which we call good carriage, graceful, vigorous action, not merely in walking, but in all of the positions and exercises which are required of the soldier.

4. The psychological elements—courage, coolness, self-control and self-reliance—should be prominently brought out.

As summarized by Hyde: "That exercise is best which reaches the largest number and does most for the weakest men. That exercise is best

which makes the hardest work attractive. That exercise is best which most co-ordinates body, mind, and will."

Physical Training in Foreign Services.—In France, Germany and Austria a compulsory system of physical training is in force in all educational institutions, both civil and military, with resulting marked influence upon the national physical development. The soldier after his enrollment continues a course of physical training with which as a boy and youth he has already become familiar, and the main features of which still remain the essentials in his military education. Among the schools of England, as in our own, no special gymnastic training is officially required, the taking of proper exercise being left largely to the individual; much to his physical disadvantage when compared with the corresponding classes of the countries just named, and to unnecessary detriment of the military service of which he may ultimately become a part.

In most foreign services the physical training of the soldier begins immediately he joins, and is continued to the end of his service with the colors. There is no such thing as a man commencing a course of physical training and being taken away in the midst of it for military drill or target practice; to return after a lengthy absence to begin again, having forgotten much that he may have been taught and lost much of the benefit he may have derived. Once started, his training continues systematically and progressively to the day he is passed into the "Reserve," he getting the maximum of benefit without the waste of time, labor and expense.

In 1842 the value of physical training for the military service was officially recognized in the German army, and schools were established for the education of instructors in this subject. The training in that army is at present comprehensive in scope, but particular importance is attached to practical and applied gymnastics, the men being continually exercised in them throughout their service. As illustrating the estimation in which gymnastic training is held in Germany it was said in a circular published in 1871: "It is acknowledged everywhere by soldiers and civilians that the astonishing accomplishments of our armies in the late war, especially their thorough discipline, exhibited in the most cheerful and self-sacrificing manner, their skill in overcoming natural and artificial obstacles in a hostile country, their courage and calmness in battle, the resolution with which they bore pain and privation, must, in large measure, be attributed to the gymnastic training of the rank and file."

France has equalled Germany, and, if elaboration of exercise, number of apparatus and multiplication of detail is a criterion, she is even more advanced in physical training. In France attempts were made in 1847 to establish physical training in the army, but no good results were arrived at owing to imperfect organization. In 1869 the Government issued a decree making gymnastics compulsory at all schools, but the operation of this law was nullified by the war of 1870. At the termination of the war, however, France awoke to the necessity of cultivating a strong race of men and a large number of athletic societies were established. In 1878 the Government made physical training compulsory in all schools, and since that time immense improvement has been made in the physical development of the French. The instruction of the recruit begins with calisthenics and gymnastics, at first without the use of weapons. It in-

cludes the movements for suppling the arms, flexions of the body and lower extremities, and also movements of jumping. These exercises are afterward repeated with arms, and later with arms and the full equipment. Following this training, a course in applied gymnastics is instituted, which include all exercises which bear on the accomplishment of feats of a peculiarly military nature.

A comprehensive and carefully prepared system of training has been laid down in the British service; the character of the exercises being officially stated to be "so arranged that while the most advanced course is sufficient to test the powers of the strongest the preliminary course can be performed without injury to the weakest frame." According to Woodhull, gymnastic drill is required one and one-half hours daily in simple movements, the older soldiers having a more extensive course. This is augmented for the foot service by a one-hour running drill daily, the training beginning at the distance of three hundred yards, and ending with one thousand yards; mounted soldiers being given extra work in fencing and single stick. As in the various continental armies, swimming is taught at all stations where the facilities exist. Some of the gymnastic exercises are accompanied by music. Special schools have been established for the gymnastic instruction of officers and non-commissioned officers; and excellent gymnasia, with simple though adequate appliances, are provided for all posts. It is officially prescribed that the exercises be not carried to the point of fatigue, and that they be varied sufficiently to avoid lack of interest.

In Austria the highest importance is attached to the physical education of both soldiers and civilians, it being compulsory in schools for both classes; but as late as 1848 the educational spirit dominant in the country was absolutely hostile to it, and it was not until the year following their humiliating defeat by the Germans that a compulsory system of physical training was put in force in all educational institutions as well as the military service—since which time it has rapidly and steadily grown to great importance.

In Russia a system of physical training was not officially established until after the Crimean War, when on the termination of that campaign, so disastrous to Russia, it was established in every military school and corps, and has been increased and improved ever since. All recruits are under instruction for four months, and in time of war for two months. The system is progressive and commences with the simplest exercises, advancing by degrees to applied gymnastics, to which great importance is attached.

In Italy, Norway, Sweden, Denmark, and Switzerland systems all more or less similar obtain, and physical culture is looked upon as necessary as, and also as being an aid to, the mental and military education of the individual.

Physical Training in the United States Service.—The American soldier cannot be regarded as an athlete or even well-trained physically. In time of peace the ordinary garrisons have been so small, and the work required of them so various, that there has been little lack of physical exercise in the sense of mere muscular exertion; but there has been largely omitted from the military life that intelligent and comprehensive physical

instruction which is essential to the equable and physiological development of the body. As expressed by Pilcher: "While the medical department has devoted ample attention to the prevention of disease by the removal of threatening conditions it has almost entirely neglected prophylaxis by increasing the resistive power of the soldier himself. It is also true that the line has been equally unmindful of so potential an agency in securing efficiency in the soldier; devoting centuries to the development of weapons of war, entirely regardless of the men who were to handle them. Having had a single object in view, the training of the soldier has been confined to the single direction of military exercise. This, having no break or variety of motion, becomes tiresome, is done in a perfunctory manner and failing in its hygienic function, leaves him overtrained in certain anatomical regions, expert only in specific muscular actions and generally but little better off physically than when he entered the service." It should be considered that if physical training has been found necessary for soldiers of European armies, all of them men who have been compelled to undergo an extended preparatory training while at school, it must be much more necessary for our men, recruited as they are from a population that has no such advantages.

Physical training should not be merely tolerated—as has been too largely the case in our service—but should be officially prescribed rather than encouraged, and proper places and appliances provided for its execution. It should be carried out under orders from the War Department, since if physical training be left to the discretion of an indifferent commanding officer the exercises are apt to become both tedious and farcical. In character and scope they should be regulated as carefully as drill and tactics; for if there be no definite requirements, no specific programme, no sufficient incentive to make of physical education the same serious business as is the case with target practice or other purely military functions, the results must always be unsatisfactory.

As expressed by General Miles: "The physical training can be made injurious to the enlisted man or of great benefit, depending much upon the care and attention of the company officers and the interest taken by the individual"—and to this might be added the necessity of intelligent medical supervision. Many zealous officers, largely unlearned in anatomy, physiology and hygiene, cannot appreciate the application of their governing laws to the proper growth of the normal man; and such, especially if lacking in experience, may illy direct or overtax the powers of the individual. At present, also, the instructors—not always themselves trained athletes—are frequently changed during the physical education of a recruit, and the advantages of a systematic course of training are thus lost. Squads, too, are composed of the ignorant, the partially and the wholly-instructed—a condition which cannot fail to be detrimental to the welfare of each individual and of the whole.

The authorized exercises should be rational and simple. The present tendency is rather to induce excellence in feats of agility and athletic sports than to develop the muscular system regularly by less interesting gymnastic training; but spectacular work should be discouraged, and the efforts limited to an honest endeavor to improve health, strength, endurance and muscular harmony.

The War Department authorities have for some time permitted the expenditure of post and company funds for fixtures and appliances for athletic sports; and, in 1889, when the establishment of canteens was authorized, official announcement was made that one of their objects was to afford the troops "the requisite facilities for gymnastic exercises—and other proper games." This plan, however, will always yield unsatisfactory results, and such an important factor in the military education should not be made dependent for its support upon meagre and infrequent allotments from unreliable sources. At each military station a suitable gymnasium should be provided and adequately equipped by the Quartermaster's Department—the apparatus being not necessarily either elaborate or costly. If possible, the gymnasium should be so planned or located as to render the shower baths available for use after exercising. At posts where much of the physical training must be done under cover the issue of proper gymnasium shoes to troops should be authorized. A cinder track, for use in connection with athletic sports, is desirable although not absolutely essential.

Schools of Instruction.—Special schools for the training of instructors in gymnastics and physical exercise are maintained in all the more important foreign military services. In the German army particularly, great value is attached to physical training. All officers are required to be proficient teachers of certain designated exercises; while one officer and several non-commissioned officers are yearly detached from each regiment and sent to large training-schools for an extended course of instruction. The central establishment is in Berlin, a section being set apart for the instruction of officers. In the British service special classes have been instituted at Aldershot and the Curragh for the training of non-commissioned officers as instructors in gymnastics. The French training-school at Joinville-sur-Pont graduates yearly from six hundred to eight hundred instructors for the army. These graduates are non-commissioned officers drawn from the several branches of the service. They are given a course of six months' training calculated to produce general physical development, and are also exercised in applied gymnastics, in practice-marching and in the construction of fortifications and entrenchments.

For the greater efficiency of our own army it is desirable that schools of the above character be established at suitable points, preferably as adjuncts to the present service schools at Fort Leavenworth and Fort Monroe. In addition to the student officers already detailed in attendance on the general course of instruction, of which the work in physical training should be a part, each regiment should be required to send yearly two non-commissioned officers to this school, thus providing a sufficient number of officers and non-commissioned officers capable of competently undertaking the physical training of the men.

II.

CONSIDERATION OF SPECIAL EXERCISES.

Attention.—The position of attention is the basis of all martial bearing, showing its effects most conspicuously when the man is in motion. While not in general looked upon in the light of an exercise its mainten-

ance nevertheless implies constant and symmetrical muscular action, which, when protracted, becomes one of the most severe tests of endurance which can be required of the soldier. When troops remain steadfast for a considerable time, as during a review, and particularly when equipped in heavy marching order, the constrained position and immobility may combine with the weight of the equipment to produce faintness and syncope.

Manual of Arms.—The manual of arms, while bringing into action the muscles of the arms and chest, is, when considered as a means of exercise, both inadequate in character and injurious in effect. The movements are not sufficiently comprehensive, and their influence upon the body is such as to render it unsymmetrical, often inducing a marked drooping of the right shoulder and in some instances, in immature recruits, manifesting a tendency toward the production of lateral curvature of the spine. To combat this unequal development a special course of training becomes necessary, and this should be carried on concurrently with the drill of the recruit.

The manual of arms does little or nothing to strengthen the soldier, but as regards certain muscles rather the reverse. These movements, limited in number as they are, require comparatively little skill in their execution when once acquired, and are performed automatically to a greater or less degree. Experience has shown that the lowest class of men learn these movements and acquire a degree of precision comparing favorably with those more highly endowed, and with practically no beneficial physical results. In this connection it may be emphasized that sound health and generally increased strength are not obtained through use and development of special muscles in the performance of specific acts, but in the synchronous and harmonious development of all muscles of the body.

The constraint and discipline accompanying the execution of the manual of arms become in a sense mechanical—thus rendering it of more advantage as a mental and moral exercise than as a means of physical training.

Setting-Up Exercises.—While every movement of the manual of arms and every evolution in drill or marching has its effect upon the muscular system, it is an error to presume that these alone are sufficient for bringing about and maintaining thorough physical efficiency. Not only by themselves are they inadequate for the maintenance of harmonious development, but, as already noted, they markedly tend to the origination and accentuation of bodily asymmetry. To remedy their serious deficiencies and defects, and to correct the vicious attitudes and unequal muscular growth imposed by various phases of military duty, the setting-up drill, so far as it goes, is most efficient. For the proper development of all portions of the muscular system, however, it is not sufficiently comprehensive in its scope, and hence might be advantageously amplified by the addition of certain of the simple movements and exercises detailed in the previous section.

From a more spiritual aspect setting-up exercise does away with much of the heaviness and *gaucherie* noted in new recruits. Straightening up their bodies to a position of grace and manly erectness, it also insensibly communicates a similar uplifting tendency to the mind—awakening the

intellect, sharpening the wit, and keeping consciousness on the alert by its innumerable demands on the mind for obedience to new orders. Finally, it trains the body to work in harmony and conjointly with the mind—an operation frequently of burdensome performance by recruits.

Infantry tactics state that "in order to retain a proper set-up and to keep the muscles supple, all soldiers in garrison should be frequently practised in the following exercises. The arm, hand, trunk, leg, and foot exercises should be alternated, the drill interrupted by frequent rests and varied by instruction in the facings, marchings, etc. While exercising one part of the body care should be taken that the other parts remain quiet, as far as the conformation of the body will allow."

First Exercise.—(1) *Arm*, (2) *exercise*, (3) *head*, (4) *up*, (5) *down*, (6) *raise*. At the command *exercise*, raise the arms laterally until horizontal, palms upward. *Head:* Raise the arms in a circular direction over the head, tips of fingers touching top of cap over the forehead, backs of fingers in contact their full length, thumbs pointing to the rear, elbows pressed back. *Up:* Extend the arms upward their full length, palms touching. *Down:* Force them obliquely back and gradually let them fall by the sides. *Raise:* Raise the arms laterally as prescribed for the second command.

Second Exercise.—(1) *Arm*, (2) *exercise*, (3) *front*, (4) *rear*. At the command *exercise*, raise the arms laterally as in the first exercise. *Front:* Swing the arms extended horizontally to the front, palms touching, heels on the ground. *Rear:* Swing the arms extended, well to the rear, inclining them slightly downward, raising the body upon the toes.

Third Exercise.— (1) *Arm*, (2) *exercise*, (3) *circle*. At the command *exercise*, raise the arms laterally, as in the first exercise. *Circle:* Slowly describe a small circle with each arm, upward and backward, from front to rear; the arms not passing in front of the line of the breast.

Fourth Exercise.—(1) *Arm*, (2) *exercise*, (3) *shoulder*, (4) *front*, (5) *rear*. At the command *exercise*, raise the arms laterally as in the first exercise. *Shoulder:* Place the tips of the fingers lightly on the top of the shoulders, keeping upper arm horizontal. *Front:* Force the elbows to the front. *Rear:* Force the elbows back as far as possible.

Fifth Exercise.—(1) *Hand*, (2) *exercise*, (3) *close*, (4) *open*. At the command *exercise*, raise the arms laterally as in the first exercise. *Close:* Close the hands with force. *Open:* Open the hands quickly, spreading the fingers and thumbs apart as much as possible.

Sixth Exercise.—(1) *Forearms vertical*, (2) *raise*, (3) *up*, (4) *down*. At the command *raise*, raise the forearms until nearly vertical, fingers extended and joined, palms toward each other. *Up:* Thrust forward with force, extending the arms to their full length. *Down:* Force the arms obliquely back and gradually let them fall by the sides.

Seventh Exercise.—(1) *Forearms horizontal*, (2) *raise*, (3) *front*, (4) *rear*. At the command *raise*, raise the forearms to the front until horizontal, elbows forced back, hands tightly closed, backs down. *Front:* Thrust the arms forcibly to the front, turning the backs of the hands up, arms horizontal. *Rear:* Bring arms back quickly to the first position, forcing elbows and shoulders to the rear.

Eighth Exercise.—(1) *Trunk*, (2) *exercise*, (3) *down*, (4) *back*. At the

command *exercise,* raise the hands and place them on the hips, fingers to the rear, thumbs to the front, elbows pressed back. *Down:* Bend the trunk forward at the hips as far as possible. *Back:* Raise and bend the trunk to the rear as far as possible. Execute both motions slowly, without bending the knees.

NINTH EXERCISE.—(1) *Trunk,* (2) *exercise,* (3) *right,* (4) *left.* At the command *exercise* place the hands on the hips as in the preceding exercise. *Right:* Bend the trunk to the right without raising either heel. *Left:* Bend the trunk similarly to the left, executing both motions slowly.

TENTH EXERCISE.—(1) *Trunk,* (2) *exercise,* (3) *circle right* (*or left*). At the command *exercise,* place the hands on the hips as in the eighth exercise. *Circle right:* Bend the trunk to the right as in the ninth exercise; turn the trunk to the rear as in the eighth exercise, turn the trunk to the left and bend it to the left, as in the ninth exercise; turn the trunk to the front and bend forward, as in the eighth exercise.

ELEVENTH EXERCISE.—(1) *Arms vertical, palms to the front,* (2) *raise,* (3) *down,* (4) *up.* At the command *raise,* raise the arms from the sides, extended to their full length, till the hands meet above the head, palms to the front, fingers pointed upward, thumbs locked, right thumb in front, shoulders pressed back. *Down:* Bend over till the hands, if possible, touch the ground, keeping arms and knees straight. *Up:* Straighten the body and swing the arms, extended to the vertical position.

TWELFTH EXERCISE.—(1) *Arms forward, palms down,* (2) *raise,* (3) *down,* (4) *up.* At the command *raise,* raise the arms to the front, extended their full length, till the hands are in front and at the height of the shoulders, palms down, fingers extended and joined, thumbs under forefingers. *Down:* Bend the trunk forward at the hips as far as possible and swing the arms backward, knees and arms straight. *Up:* Straighten the trunk and swing the arms to the upward position.

THIRTEENTH EXERCISE.—(1) *Leg,* (2) *exercise,* (3) *half bend,* (4) *down,* (5) *up.* At the command *exercise,* place the hands on the hips, as in the eighth exercise. *Down:* Lower the body, separating the knees and bending them as much as possible, heels on the ground, head and trunk erect. *Up:* Raise the body, straightening and closing the knees.

FOURTEENTH EXERCISE.—(1) *Leg,* (2) *exercise,* (3) *full bend,* (4) *down,* (5) *up.* At the command *exercise,* place the hands on the hips as in the eighth exercise. *Down:* Lower the body, separating the knees and bending them as much as possible, head and trunk erect, heels raised, weight of body resting on the balls of the feet. *Up:* Raise the body, straightening and closing the knees, and lower the heels to the ground.

FIFTEENTH EXERCISE.—(1) *Leg,* (2) *exercise,* (3) *left* (*or right*), (4) *forward,* (5) *rear, or ground.* At the command *exercise,* place the hands on the hips as in the eighth exercise. *Forward:* Move the left foot to the front, knee straight, so as to advance the foot about fifteen inches, toe turned out, sole nearly horizontal, body balanced on right foot. *Rear:* Move the leg to the rear, knee straight, toe on a line with the right heel, sole nearly horizontal. When the recruit has learned to balance himself the command *forward* is followed by *ground.* Throw the weight of the body forward by rising on the ball of the right foot, advance and

plant the left, left heel thirty inches from the right, and advance the right leg quickly to the position of *forward.*

SIXTEENTH EXERCISE.—(1) *Leg,* (2) *exercise,* (3) *up.* At the command *exercise,* place the hands on the hips as in the eighth exercise. *Up:* Raise the left leg to the front, bending and elevating the knee as much as possible, leg from knee to instep vertical, toe depressed. *Up:* Replace the left foot and raise the right leg as prescribed for the left.

SEVENTEENTH EXERCISE.—(1) *Foot,* (2) *exercise,* (3) *up,* (4) *down.* At the command *exercise,* place the hands on the hips as in the eighth exercise. *Up:* Raise the body upon the toes, knees straight, heels together. *Down:* Lower the heels slowly to the ground.

These exercises, though simple, are fatiguing; and the various groups of muscles are best brought into action for brief periods only. The exercises in general, and particularly any one movement, should never be carried to excess, since under such circumstances, especially when the heart is irritable, faintness is readily induced in untrained recruits. Particularly is this true of the third exercise.

Fencing.—This exercise is of particular value in producing chest development. It brings into play all the muscles of the body and ensures agility and soundness of wind as well as decision of character and rapid co-ordination. It has the disadvantage, if used to excess, of inducing an exaggerated development of the side holding the foil, together with scoliosis, the concavity of the spine corresponding with the sword arm. On the same side the shoulder is dropped and the chest flattened. These faults, however, may be avoided by fencing with each arm alternately. To avoid injuries the mask should be so rounded that the foil can scarcely strike perpendicularly; while the mesh of the mask itself should be small, as also the button on the foil. Due care should be taken to protect the hand of the sword arm from injury—but constant exercise in fencing tends to produce contraction of the fingers. Both the faults and advantages of fencing exist in less degree in sabre exercise.

Bayonet Exercise.—The primary object of bayonet drill is to render the soldier quick and proficient in handling his piece, but it also serves as a most valuable physical exercise, expertness depending largely on quickness and accuracy of motion. Eleven movements are laid down in tactics; but the number is not restricted, the addition or selection of other exercises being left to the discretion and ingenuity of instructors. This drill supples the soldier, gives firmness of footing, increases muscular strength and removes awkwardness. It has, however, the general fault of all purely military exercises in that it favors unilateral development.

Target Practice.—This is important as a form of exercise. It has the advantage of being carried on in the open air; and constitutes, with its varying positions and movements, a species of gymnastics requiring for its performance the ready co-operation of vision, muscles and nerves, checking each shot with the immediate result. It is not, however, without drawbacks. When smokeless powder is used, and the shooting is done against the wind, the fumes from its combustion, inhaled by the marksman, often induce cerebral congestion and severe headache. At the longer ranges, particularly if the sun be high and heat waves induce refraction, eye strain is frequently developed. Banister states that the latter

affection is diminished in frequency, and that better scores are made, if the body of the target be black and the bulls-eye and rings be buff. This obviates the reflection of light, and at the same time produces a greater contrast between the color of the target and the face of the landscape. He also recommends that the prone position be the only one allowed in recumbent firing and that the side and back positions be excluded, as causing congestion of the intra-ocular tissues by compression of the blood vessels of the neck.

In small-arms practice the markers are exposed to the dangers of gunshot if due precautions for their safety are not carefully observed, and the same applies also in less degree to the marksmen themselves.

In artillery practice the atmospheric vibrations often result in injury to the auditory apparatus. During the recent Anglo-Boer war, Müller found marked changes in the auditory apparatus in forty-four out of ninety-six soldiers examined before and after a battle, while many of the artillerymen were made partially deaf or suffered from buzzing in the ears. To avoid possible rupture of the tympanum, hemorrhages from the eyes and ears, deafness and subjective noises, the artillerymen should stand well behind the piece and habitually open the mouth at the moment of firing to equalize the air pressure on both sides of the tympanum. The use of cotton wadding in the ears, to break the force of the atmospheric waves, is always advisable. Léques noted that injuries to the tympanum became much less frequent after breech-loading ordnance was adopted; on the other hand the use of nitro and smokeless powders appears to favor them.

Practice Marches.—Marching is the most important of military exercises. It has been laid down as an axiom that the soldier who cannot shoot is useless and an incumbrance to his battalion, and incontestably the same might be said with an even greater degree of truth as regards the soldier who cannot march; for whereas the former may conceivably find himself in a position where accuracy of aim is unnecessary, the man unable to keep up with his comrades is not only an incumbrance but becomes in an enemy's country a positive source of danger. Not only should troops be able to march rapidly, but they should be able to cover a considerable distance in full campaign order. It is also a desideratum that they should do this without undue fatigue; and that not only should they be able to take part in an engagement, but should, in the event of necessity, have sufficient residual energy to take part in a pursuit. Napoleon has been credited with the dictum that the secret of success in war lies in being able to march ten leagues, fight a battle, and march ten leagues afterward. If this was true of his day, it is even truer of our own.

To enable the recruit to fulfill the above requirements properly it is evident that careful training is necessary. According to Austin, of the defectively trained British troops in the field during the annual manœuvres of 1895, a large number were found unable to sustain the task assigned them; and of one division, in a single day, eight hundred and thirty-five found it necessary to fall out. Since that time British regulations explicitly provide that practice marches are to be progressive, beginning with nine and gradually increasing to sixteen miles. The training culminates annually with a six days' march during which the battalion is required to cover one hundred miles. In the practice marches of the French army the

recruit commences at the distance of 16 kilometers, and this is gradually increased to 30 kilometers. Finally he is given four successive days of marching under the full equipment, the distances being 22, 24, 26, and 28 kilometers. With the French recruit, after some training, roads are abandoned and the command marched over open country. The course of training in vogue in the German and Russian armies is similar to that of the French. In our own service no special regulations as to this training exist; in this respect, as in others, too much being left to the discretion of the local commanding officer. Troops are expected to make a practice march of mild character and not too long duration, annually; but there are no requirements as to the course of training which properly leads up to such marching. This method is obviously faulty, and it is certainly unfortunate that the question of the systematic training of the soldier in this most important part of the military curriculum has not received more careful attention at the hands of the authorities.

It cannot be said that free and graceful carriage, one of the essentials of correct physical training, is brought about by exercise in marching. In this drill the man is taught to march upright and stiffly, and look straight to the front. Every movement is constrained, and natural motion of the trunk or upper limbs is denied, thus stopping the action of muscles necessary for their development—and this at a period in the career of the soldier when every effort should be used for such development. Without correcting exercise, the individual undoubtedly acquires an accuracy of step and correct alignment in marching, but existing physical defects are unremedied and some are exaggerated. The effect of marching, when well regulated, is, as might be expected, unquestionably beneficial to the general health of the soldier. He gains in weight, the muscles become firmer and well developed, the face becomes ruddy and free from all signs of anæmia. When marching is injurious the effect is found to be precisely the reverse: there are loss of weight, muscular flabbiness, anæmia, and a haggard, drawn appearance. The several phases of marching, apart from its uses as a means of instruction or exercise, are fully discussed in the next chapter.

Running Drill.—Short drills in running are desirable from a military standpoint as well as excellent as a gymnastic exercise. They should not, however, be given too frequently, should commence with very short distances, and even after very long practice should never exceed ten or fifteen minutes' duration. Drills at the double will first be without arms or accoutrements. After some practice, the armament, canteen and haversack may be added, but running with the full field equipment should at no time be indulged in. Commencing slowly, the pace should be increased to the middle of the run and then gradually decreased. The men should run entirely on the ball of the foot, striking the ground lightly, since running on the flat foot is both fatiguing and awkward and on rough ground sprained ankles frequently result. Men showing any evidences of cardiac weakness should never be allowed to run. In this drill recruits should be encouraged to fall out at will, for a heart may very easily be irreparably overstrained, and an exercise intended to strengthen the man may ruin him for life. Even when permitted to fall out the overtaxed soldier will frequently endeavor to complete his task; being spurred on by a desire to excel, to hide his weakness and to escape the banter of his

comrades. Hence the instructor should observe the men carefully, and be alive to the first symptoms of cardiac and respiratory embarrassment, as well as those of actual exhaustion.

Instruction in double time is given the importance it deserves in various foreign armies. In the English service the regulations prescribe a running drill, in addition to the general physical training, for all infantry regiments; it being intended that each man should ultimately be able to run one thousand yards without being too disturbed to use the bayonet, if it should be necessary. In the French army, running drill is given with and without the full equipment, is limited to two periods weekly, and the distance traversed must not exceed 120 meters. The distances prescribed for training are 60, 80, 100 and 120 meters respectively.

Equitation.—This is the most important exercise of the mounted service. It brings into use certain previously undeveloped muscles of the leg and thigh, increases the appetite, promotes assimilation of food and mechanically aids the action of the intestines. Horse exercise is productive of hemorrhoids and frequently induces hernia. It has been accused of causing varicocele, atrophy of the testicles and impotence, but these claims have scarcely been substantiated. Excoriations from riding are somewhat common in recruits but are of less importance than blistered feet in the case of the infantryman, and are also much less frequent. To prevent such abrasions the painful spots should be washed and greased, while the drawers should be clean, soft, and well fitting. Furuncles are quite common among mounted troops. They usually occur on the buttocks, through pressure and irritation by unclean and sweaty clothing. When the pustules break, the pus and contained micro-organisms are frequently rubbed into other parts of the skin, thus forming new points of infection.

On account of the uncleanly duties which the mounted soldier is required to perform frequently, he must watch with care his bodily cleanliness, and washing after returning from stables, together with frequent bathing of the person, should be the rule.

Work in the riding-hall is much less healthy than when carried out in the open air. The atmosphere of the riding-hall is charged with a fine dust composed chiefly of microscopical splinters of wood, dried fecal matter, urine, and bacteria; and this, when inhaled, is both irritant and dangerous.

Since some maladies of the horse can be transmitted to man, all sick animals should be promptly isolated, and the equipments thoroughly disinfected. Such men as have charge of sick horses should change their outer clothes and wash themselves well with soap and a disinfectant solution after performing their duties and before returning to barracks.

Natation.—As a military accomplishment, and apart from its hygienic advantages, all soldiers should be taught swimming; since they are thus rendered independent in case of accident or when it becomes necessary to cross a deep water-course during action. In every station near a suitable body of water, exercises in natation should be instituted during the proper season.

Swimming combines the tonic and cleansing effect of the cold bath with general muscular exercise, without the disadvantage of being accompanied by heat and perspiration. It should not be required in water having a lower temperature than 65° to 70° F., nor should it immediately

follow eating or severe exercise. Soldiers en route to the bathing-place should march slowly and not arrive sweaty; although if men swim or exercise vigorously and not merely bathe and paddle in the water, there is no harm in going into the water while moderately perspiring. Colds are caught by standing undressed waiting to cool off, and no time should usually be lost in wetting the head and then entering the water. Under ordinary conditions, remaining in the water more than half an hour is inadvisable, and under any circumstances the exercise should be concluded on the slightest feeling of chilliness. Most persons unable to swim do not take sufficient exercise, especially if the water be cool, and such are prone to chill the body by sitting or standing on the bank, undressed, after having been in the water. The exercise should be supervised by an officer, assisted by the best swimmers of the command, and these should require the maintenance of constant activity and effort on the part of all. Since swimming is a source of danger, instruction in the art requires careful surveillance, while the bathing-place should be carefully explored and the limits of safety for non-swimmers sounded out. In anticipation of possible asphyxiation by submersion, certain individuals of the command should always be proficient in the methods employed for the restoration of the apparently drowned, including Sylvester's method of artificial respiration and Laborde's tongue traction. Bathing is somewhat liable to induce ear trouble, and individuals so affected should not be allowed to participate in this exercise. The men should be cautioned against swimming under water on account of danger to the hearing, and on coming out should be instructed to incline the head to enable the water to escape from the ears. Certain individuals will often present a severe erythema as a result of cold bathing, and such should be excused by the medical officer, who should also fix the time and duration of the bath.

Gymnasium Exercise.—Infantry tactics prescribe that where there is a regular system of gymnastic instruction it may replace the setting-up exercises for well-trained soldiers; it being recognized that with the latter movements it is impossible to obtain such muscular development and control as follows the intelligent use of gymnastics. Exercise in the open air is always preferable to that indoors; but the gymnasium is the only place where every muscle can be most readily exercised, and has the great advantage of being available when drill and other military duties have to be suspended on account of inclement weather. Although a well-equipped gymnasium is naturally desirable, yet its main advantages for the development of the recruit may be obtained where a large building is available, and at the expense of but a trifling outlay for dumb-bells, Indian clubs, and carpenter work. If to the kinds of apparatus just named, the parallel bars, vaulting horse, rings, hanging rope, horizontal bar, spring-board, and chest weights be added, the outfitting of the military gymnasium becomes practically complete, and the further multiplication of apparatus may be regarded as an unnecessary refinement. A few simple, well-selected exercises with these appliances, thoroughly carried out, leave little to be desired.

The men must be taught how to exercise and use the apparatus; since if not started in the right way they are liable to stand around helpless, imagining that as they cannot turn handsprings or perform other showy

feats there is nothing left for them to do. Energy and life should instilled into the drill, and much better results will be obtained if instruction be given more by example than verbal direction. For this reason the delegation of the gymnastic drills to younger officers is highly desirable.

Work in the gymnasium should be used to supplement the setting-up exercises, and not to their exclusion. General development should be aimed at rather than the enlargement of any special group of muscles—a proceeding which, for military purposes, is of little or no value. The lighter and simpler exercises should be the compulsory ones, but encouragement should be extended to those men who show special aptitude for more difficult gymnastics. A few skilled gymnasts and athletes serve an excellent purpose in a military command, since they are of use not only as instructors but also raise the standard to which the average man endeavors to conform. It should never be lost sight of, however, that in the military service the mass must be trained—not the individual athletes.

As a general rule, light gymnastics develop the muscles more uniformly and increase the capacity of the lungs much better than do acrobatic exercises. After a certain amount of lung power and endurance has been obtained, it is only following the heavier work that frequent rests will be required; since the exercises may be so varied that one part of the body can be rested while another is being exercised.

When properly conducted the gymnastic work cannot fail to be attractive, and the men will look forward to this feature of their life as a pleasure rather than an arduous duty, and as a welcome break in the monotony of the tactical drills.

Men with hernia and a few old soldiers who, by reason of age or infirmity, have lost their agility, to whom the gymnastic exercise would be of no benefit, should be excused altogether from the drill. Such men as have largely lost their suppleness of joints but are still fit for active service should be required to fall out before each drill and, under the charge of an instructor, be given a few minutes of light and entertaining exercise.

Wherever practicable there should be five drills weekly, each drill to be of at least thirty to forty-five minutes' duration.

Applied Gymnastics.—Following a general course of physical training, the French and Germans—and to some extent the English—accustom their troops to the overcoming of such obstacles as may often be encountered in actual warfare. These exercises, known as "applied gymnastics," are practised first in light garb and without encumbrance, the soldier being gradually worked up to executing the movements under arms and with the full field equipment. The practical character and comprehensiveness of these exercises is well shown in the following description of the conditions under which the work is reported as being now carried on in the German service: "The course was U-shape, one hundred and ninety-five paces long and eighteen feet broad; the obstructions being arranged in the following order:

"1. A ditch, six feet wide, for the running jump.

"2. A mound of earth, three feet high and four feet wide, for the high jump.

"3. A ditch, twelve feet wide, for the broad jump.

"4. A mound, six feet high and ten feet wide at the base, on the edge of a ditch twelve feet wide, for the 'deep leap.'

"5. A board fence, five feet high, to be vaulted over.

"6. An escalading stage, twelve feet high and six feet wide at the top, to be climbed by ladders, ropes, or poles, and jumped or dropped from.

"7. A ditch, ten feet deep and nine feet wide, bridged by a shaky beam and with an escarpment wall rising four feet above the hither edge of the ditch.

"8. A palisade, seven feet high, built of sharpened planks.

"9. A glacis.

"A section of twelve men in three ranks of four each, with muskets, side arms, and knapsacks, habitually made the entire course, from end to end, in three to three and one-half minutes. Without weapons or knapsacks, four men usually covered the course in sixty to seventy seconds; and a few individuals were able to surmount the obstacles in forty-five seconds."

Of the advantages occurring from such exercises Mutel says: "The soldier well trained in (applied) gymnastics knows how to jump considerable heights, with or without his arms. He is able to cross streams or precipices with the trunk of a tree for a bridge and can pass over walls, ditches, or ravines, aided or not by such instruments as may be available, either with free hands or carrying a burden. He is accustomed to the escalade with or without the use of the ladder or knotted rope; to climb to the top of trees and to descend readily; to carry weights with address and security without bodily suffering or inconvenience, and to transport the wounded."

In our service but little work of this character has been done in spite of its obviously great practical advantages. Through the efforts of Butts a few soldiers have lately been trained in the escalade and kindred exercises, but the work has unfortunately been looked upon as spectacular rather than as possessed of actual military value. Besides greatly conducing to general efficiency and a sound bodily development, such a system of training would in a short time disclose the latent defects of physically imperfect individuals and result in their early elimination from the service to which they are certain to be but a useless expense and encumbrance. It is much to be hoped that a course of exercises of this character may be officially incorporated into the military curriculum.

Guard Duty.—Whether in camp, garrison, or on picket, and particularly when superadded to the fatigue of the march, on account of the responsibility and vigilance which it imposes and the loss of sleep which it entails, guard duty is the most exacting and wearing that befalls the soldier. Ordinarily, guards are relieved every twenty-four hours, during which period the soldier may remove neither his clothing nor accoutrements; while he is on post and alert for two hours, with an interval of four hours' rest, four times during the tour. While under ordinary conditions this plan is not seriously objectionable, during periods of severe cold or great heat the sentinels should be changed more frequently or else the system of running-guards instituted. In the latter case the whole period is so divided that any particular soldier goes on but once in his tour or once during the night, and is able to rest during the remainder of the time. The guard must be larger than usual in order not to keep one man on post

too long a time, but the compensation lies in the uninterrupted rest before and afterward. As sufficient sleep is indispensable, so its loss is followed by a degree of lassitude and discomfort amounting in many to actual suffering, especially in the case of recruits; and there is no doubt but that deprivation of accustomed rest is a potent factor in the production of a lowered resistance through which invasion by disease is favored.

While young soldiers must necessarily take their share of guard duty, their tours should preferably not be in the first hours of the night, when the mature are wakeful and the young are disposed to sleep. Under this plan the older men will also receive their rest at a time when nature most prompts them to seek it. In war, night guard is very frequent, and rest must be completely subordinated to the necessity of guarding against surprise—this usually occurring at a time when the fatigues of campaign are greatest. In addition to the inclemencies of the weather, sentinels are unduly exposed to infection by disease, particularly that of a malarial nature. If hard-tack and a bowl of hot coffee be served out to the men just before going on post late at night—and this can usually be arranged—it is of decided advantage in preventing sickness. Guards in a distinctly malarial region should be given five grains of quinine at retreat, and should be required to wear flannel next the skin. Due care should be taken that the clothing worn should be suited to the duty and weather. The custom prevailing in many European countries of having the sentries belonging to the regiments of the guards posted in full dress uniform is a useless sacrifice of the hygienic to the æsthetic.

It is the nights on guard in all kinds of weather and with heavy responsibility which break men down most rapidly. A tour of guard duty for a seasoned soldier should not occur oftener than once in five days, nor for a recruit oftener than once a week—and the longer the interval the better for the health. Too frequent guard duty is a potent factor in increasing desertions.

Other Exercises.—Soldiers of all branches of the service, especially of the engineers and artillery, should often be exercised in the throwing up of entrenchments, instructed in the building of roads, construction of mines, and similar duties. This kind of work, done in the open air, is very salutary if it be not carried to the point of extreme fatigue. In campaign, however, the work of fortifying becomes both laborious and dangerous, and it involves great exposure to fatigue associated with the action of heat or cold. The opening of the ground in a malarial country offers dangers which are to be palliated by the prophylactic use of quinine, choice of hours for the work and attention to the location of the camp during the night.

Skating affords excellent exercise, but is usually considered rather in the light of a pastime. In Holland and to some extent in Russia, however, the troops are taught to drill and manœuvre on skates.

Snow-shoeing is valuable, and is included in the military training in the armies of Norway, Sweden, Austria and Russia.

Athletic Sports.—These, through the spirit of competition which they arouse, are a powerful factor in stimulating interest in physical exercise and do much to render even the hardest work attractive. Many sports, however, call for an irregular physical development; especial

proficiency requiring that certain muscles be cultivated to the exclusion of others. This class of exercises should not be encouraged in the military service, and hence such exercises as the pole vault or throwing the shot and hammer are undesirable. The tug of war, so popular among soldiers, is liable to induce heart strain, and is possessed of no particular advantage in the military education. Long-distance running—as in "hare and hounds"—much praised by some, is not to be advised in the physical training of the soldier. Williams found that of eleven trained athletes who participated in a cross country run all had lost weight, one as much as six pounds, and all were exhausted, cyanotic, and presented weak cardiac action. Boxing and wrestling are admirable, the latter being the best of all single exercises. Besides developing every muscle in the body the last two exercises impart confidence and self-reliance, and may often be of direct value in the exigencies of military service.

Interest in baseball, football and other manly games should be stimulated in every manner; and as many men as possible should be encouraged to participate in the training. Football, above all other sports, is the game of the soldier, since it develops strength, agility, coolness, fearlessness, and determination, all subordinated to a leading mind in perfect discipline. Beyer found that the total strength of seventeen naval cadets, averaging nineteen and one-half years of age, and having an average height of 1.765 meters, was increased, in one month of practice at football, no less than 17.15 per cent.—or nearly by one-fifth. When properly played by adequately trained men, this game is largely free from the danger of severe accidents. Strains often occur and bruises are common; but the severe and sometimes fatal injuries which are recorded are received practically only by the untrained and by immature and undeveloped boys. A recent investigation of football, as played at the three great universities of Yale, Harvard, and Princeton, showed that in ten years less than a dozen broken bones had been incurred at those institutions. This showing emphasizes the fact that careful preliminary training, consisting of running, dodging, tackling, and, above all, of learning how to fall on the ball and to be thrown so as to receive no injury, practically eliminates all valid objections to this admirable exercise for the soldier.

It may be remarked, in passing, that the athletic spirit now so much cultivated in colleges, athletic clubs, and similar organizations is of peculiar value in connection with the military strength of the nation, in that it does much to render available, in case of an emergency, a large number of young men trained in bodily exercise and readily receptive of military instruction.

III.

MENTAL AND MORAL EDUCATION.

To the training of the body should be joined that of the mind, to inculcate the spirit of discipline in the soldier. Raw or ill-disciplined troops are always sickly as a result of their own ignorance and indiscretion, and hence the moral training has an important bearing on hygienic results.

The soldier should be of manly character, willing, brave, steadfast, zealous, enthusiastic, of good humor, and possessed of initiative. At all

times there should be exacted complete subordination, outward manifestation of respect to superiors, precision and correctness in exercises, and that temporary effacement of the personality which makes the man in the ranks a part of an intelligent machine to act at the voice of the commander. The latter requirement has always met with opposition in this country and to it has undoubtedly been due a large proportion of our military calamities. Individuality of thought and action is jealously guarded as the heritage of a republican form of government; and this idea, when carried into the army, constitutes a serious military defect. In the history of the United States Sanitary Commission, published in 1866, Stillé wrote: "This strange infatuation pervaded all ranks of the people, and, as it seemed a foregone conclusion that discipline such as that which existed in other armies could not be enforced in ours, of course little effort was made to introduce it in the volunteers. The effect was soon apparent. The ignorance of the officers concerning their duties was manifested at the first test. The injury to the health of the troops and, therefore, to their morale and efficiency, mainly due to the ignorance, incapacity, and carelessness of the officers, is now known to have been absolutely disastrous." These remarks might have truthfully been written of our volunteer troops during the Spanish-American War, carried on a full generation later.

Tonnochy believes that the mental education of the soldier should include the blunting of the instinct of self-preservation so far as it can be attained in the living being, and that the individual should be so trained that he is not afraid to be destroyed if only his destruction cost the enemy dear. It is obviously true that the soldier must be taught to accept with resignation the misfortunes of war, and to support with composure the fatigue and privations which are always the price of victories. He should possess a desire for service and glory, should take pride in his uniform and duties, and, over all, entertain a patriotic love for his country. This idea of patriotic devotion and sacrifice serves as a powerful incentive to the soldier; and moral force, according to Bugeaud, is equal from a military standpoint to the physical force, through the constant stimulus to activity which it engenders.

Religious feeling, apart from its moral aspect, is a potent factor in military efficiency, and has been a dominating factor in many military movements. The most difficult peoples to conquer are those fanatics who believe themselves the inspired agents of the Deity, and whose religious teachings lead them to court death in the effort to destroy the unbelieving enemy.

Education is of value from the military standpoint purely as it enables the soldier better to perform his duty. Hygienically considered, education is important since it broadens the character of the soldier, raises the standard under which he desires to live, and induces a better appreciation of the inevitable and disastrous results which must follow the commission of sanitary faults. Libraries in regiments or military posts are of great value. While containing standard fiction as well as science, they should include historical works, particularly such as express patriotic sentiments and relate the deeds of great commanders. Books pertaining to the care of the health in the military service, and especially those which are devoted to physical development, will prove interesting and desirable reading.

In conclusion, it has been well written by Woodhull: "As a consequence of efficient military hygiene, which involves moral as well as physical training, the average recruit at the conclusion of his enlistment is a better man in mind and body, if his company has any discipline worthy of the name. He has learned obedience, responsibility, promptness, order, the value of co-operation and attention to his own duty as moral qualities; and the importance of cleanliness, of regular habits and sufficient bodily exercise as physical ones. The slouchy, dirty, careless and perhaps insubordinate rough becomes the erect, neat, and disciplined man-at-arms, distinctly charged with the preservation of the peace."

CHAPTER III.

THE MARCH IN CAMPAIGN.

In the disposition of the march certain hygienic as well as strategic elements must enter, the former being those of season, weather, physical character of country and the condition of troops. It is evident that if the character of the march be so imprudently designed, in its length or detail, as to fatigue and harass troops, a commander will succeed in breaking down the strength and spirits of his soldiers; so that the more he marches and the nearer he approaches the enemy the less fit he will be for the encounter. In a hostile country it is always advisable to keep troops fresh and make only short marches, for fatigue and exhaustion are as inimical to courage and initiative of action as they are to physical endurance. As far as possible military restrictions of an unnecessary nature are to be avoided, since in marching at ease the ordinary journey is relieved of much of its harassing character and becomes a salutary and stimulant exercise. The men are more cheerful, more contented and capable of higher measure of endurance. The movements of the individual soldier should not be restrained by precise military rules, but should occur more easily in the better maintainance of equilibrium.

Preparation.—Prior to active operations in a foreign country it is desirable to thoroughly understand the climatic conditions which will be encountered. Such knowledge will not only assist in the outlining of the campaign, but will render it possible, should such action be necessary, to alter plans with advantage. If an enemy be drawn into an unhealthful situation and compelled to stand on the defensive or remain under observation under such conditions, more ultimate benefit may be derived from the depletion of his ranks by disease, and the filling of his hospitals, than by a victory dearly purchased in a doubtful conflict. On the other hand, a knowledge of the medical topography of the theatre of war will perhaps prevent the drawing, by a seasoned enemy, of troops unaccustomed to the country, to insalubrious regions where both disease and the enemy must be combated.

In preparing for an active campaign or long march, all cases of slight illness or disability should be carefully segregated and left behind, since such soldiers may be considered as practically certain to break down at an early date and become an encumbrance to a marching column. Especially does this apply to the detection and elimination of concealed or partially cured venereal disease, the symptoms of which are notoriously aggravated by such prolonged and arduous exertion or exposure as are inevitable in campaign. Such cases, after recovery, may be later forwarded as reenforcements, and thus become a source of strength instead of weakness to the command. It is well to remember, in this connection, the spirit of

military ambition which prevails among such forces as are raised by voluntary enlistment, as is the case in the armies of the United States and Great Britain. Such soldiers, particularly in time of war, are eager to participate in active service. Inspired by the desire to accompany their respective commands on campaign, and buoyed up by nervous excitement and fictitious energy, men carried on sick report will often, wilfully or innocently, favorably misrepresent their physical condition to the medical officer in order to obtain consent for their return to full duty. Great care must always be observed that such men, in spite of their praiseworthy desires, are not permitted to engage in a march for the accomplishment of which their strength is inadequate. Under the best of circumstances, according to Wolseley, in a division of infantry marching one hundred miles, the probable loss may be estimated at two to three per cent. This percentage may, of course, be increased by climate, weather, condition of roads and other factors.

Troops should never be marched fasting, for such action increases fatigue, lessens resistance and breaks down the barriers against disease. While European armies will make a march on merely bread and coffee, our troops require a much more substantial meal. Experience has shown that laborers in tropical countries, accustomed to work until late in the forenoon with no refreshment except a cup of black coffee, are capable of accomplishing much more if provided with a hearty breakfast before beginning their task.

The Step.—The military marching step, as a means of locomotion, must be considered as far more fatiguing than ordinary walking, since the movements of the soldier are, to a certain degree, unnatural and constrained; the ease of the individual being somewhat sacrificed to precision of action. Hence the value of scientific computations as to the work performed by ordinary pedestrians is much diminished in the case of the soldier on service.

Until within the past generation it was considered that military methods and customs must necessarily be artificial, and nothing was too constrained or even grotesque if it appeared to contribute to the precise manners which were supposed to characterize the military man. Hence it is not surprising to find that until only comparatively recently the left arm was held firmly against the side in marching, much to the interference with the equilibrium of the soldier; and that, on account of its striking effect on parade, a peculiarly exaggerated high step, in which the thigh was elevated to almost a right angle with the body, was for a long time cultivated in certain European troops and only abandoned through the physical impossibility of travelling any but the shortest distances in such a manner.

Under present methods of marching the shoulders must be kept straight and the neck and body held erect. The knees are only slightly flexed, and the feet are thrown out well in advance of the body, but the free arm is allowed to swing naturally to better maintain the balance. Such a manner of progression is not that voluntarily employed by the individual, and hence, on long marches or campaigns or whenever energy is to be conserved, the use of the route step is always advisable. In ordinary walking, the heel touches the ground first; the greatest weight being borne by the flat of the foot, and the toe leaving the ground last. Hence the prac-

tice in the German army, as well as our own, of training the marching soldier to place the foot almost flat upon the ground, increases the shock of impact and is more fatiguing to the individual, especially on a rough



FIG. 4.—Military or Straight-leg Marching. (After Bradford.)

terrain. When the leg is at its greatest length, and is lifted from the ground, it is brought forward to a position under, or slightly in front of, the body, by the force of gravity and without muscular exertion; the action of gravity being also exerted to a certain degree outward. From this point the leg is advanced through the distance required for the next step by the action of the vasti muscles and the straightening of the limb. The foot acts like a lever of the second order, as shown in the accompanying diagram (Fig. 5), the fulcrum being at A, the resistance—represented by the weight of the body—at R, and the power at P, where the muscles are inserted into the calcaneum.

In the ordinary military marching step, the toes should be directed well forward so that the thrust backward in the foot, and especially on the great toe, should be in the direction of its length rather than to a certain extent across it; since the muscular action of the great toe is one of the most potent agents in the propulsion of the body forward. The foot is anatomically so constructed as to support the body weight from the heel, the ball, and the outer portion of the sole; the inner portion of the plantar surface being concave and not normally coming in contact with the surface over which the individual moves. The more the eversion of the foot, the less the body is supported by the outer surface of the sole and the greater the tendency to break down the plantar arch through the increased weight which must be borne upon its extremities, the heel and ball of the foot. Marked eversion of the foot, such as



FIG. 5.

was formerly carefully inculcated in many European armies, could only result in placing the marching soldier at an anatomical disadvantage which increased his labor, fatigue and discomfort, and directly tended to permanently impair his efficiency by the production of flat feet. On the other hand, inclination of the foot outward to a slight extent favors the muscular action of the smaller toes and better preserves the equilibrium of the body by affording a broader basis of support over which the body passes in its advance to the front. A moderate inclination outward, of about ten or twelve degrees, probably best answers all requirements. The foot should be raised from the ground only so far as is necessary to clear obstacles.

The marching step recently strongly advocated by de Raoul, of the French army, was previously unknown to civilized nations, but is commonly employed in the Orient; especially among the couriers and footmen of Japan, Ceylon, and India, who are able to cover their seventy-five miles daily for months at a time without great physical effort or serious effects. In this step, known in France as the "pas de flexion," the hips, knees, and ankle joints are slightly bent, the body is inclined forward and the feet are placed on the ground with little emphasis. According to de Raoul this method is far less fatiguing than the ordinary marching step, since in the latter the body rises and falls to an excessive degree and so unnecessarily increases one of the principal ways in which muscular force is lost. It has been photographically demonstrated, also, that the vertical elevation of the body is more than two inches in the ordinary step, and less than one inch in the "pas de flexion." Such a difference at first sight appears to be trivial, but it has been shown by Marey that in marching a mile with the flexion step the energy saved in the lessening of the vertical oscillations of the body was sufficient to elevate the individual through the vertical distance of one hundred and fifty feet—an economy of energy somewhat surprising and well worth consideration. In the Raoul method the body above the hips is inclined forward to such a degree that the centre of gravity is constantly on the point of being lost, and the only way to prevent falling forward is to keep in motion; when, as the centre of gravity moves forward, it drags the weight of the body with it without muscular action. To keep pace with this movement with the least effort, the foot should be only slightly raised and should be brought into contact with the ground glancing rather than flat, thus lessening the shock of impact. The pressure on the ground is also said to be lessened. To train in this method, short, quick steps, one hundred and sixty to the minute, are at first required; their length being gradually increased. The step is noiseless, and the toes are directed toward the front. The distance traversed, as practised in the French army, begins at three thousand yards and increases up to twelve thousand yards. Lessons are preferably given but two or three times weekly, and it is said that a three months' course of training is necessary for proficiency in this step.

According to Viry, experiments in France have repeatedly demonstrated that the fully equipped soldier, if trained in this step, can easily attain a rate of eight miles per hour. Of two officers and thirty-two men who were put under training at Nantes it was recently reported that "after three months' instruction, they marched, carrying their rifles, bayonets, one hundred rounds of ammunition per man, and food for one meal, along

a hilly road, a distance of twelve and one-half miles, in an hour and forty-six minutes, which is at the rate of rather over seven miles an hour. Not one man fell out by the way. After a rest of two hours, they returned in three hours and five minutes, including two halts of ten minutes each, which gives an average speed of over four and one-half miles an hour. Two days afterward these same men, in heavy marching order, covered a distance of six and seven-eighths miles across fields, on hilly ground, in an hour and twenty minutes, which works out at about five and one-half miles an hour. At the end of their march they were at once told off to target practice, when their shooting proved superior to that of the best company of marksmen in the regiment; this was done to determine whether the exertions of their rapid march had injured their capabilities as riflemen."

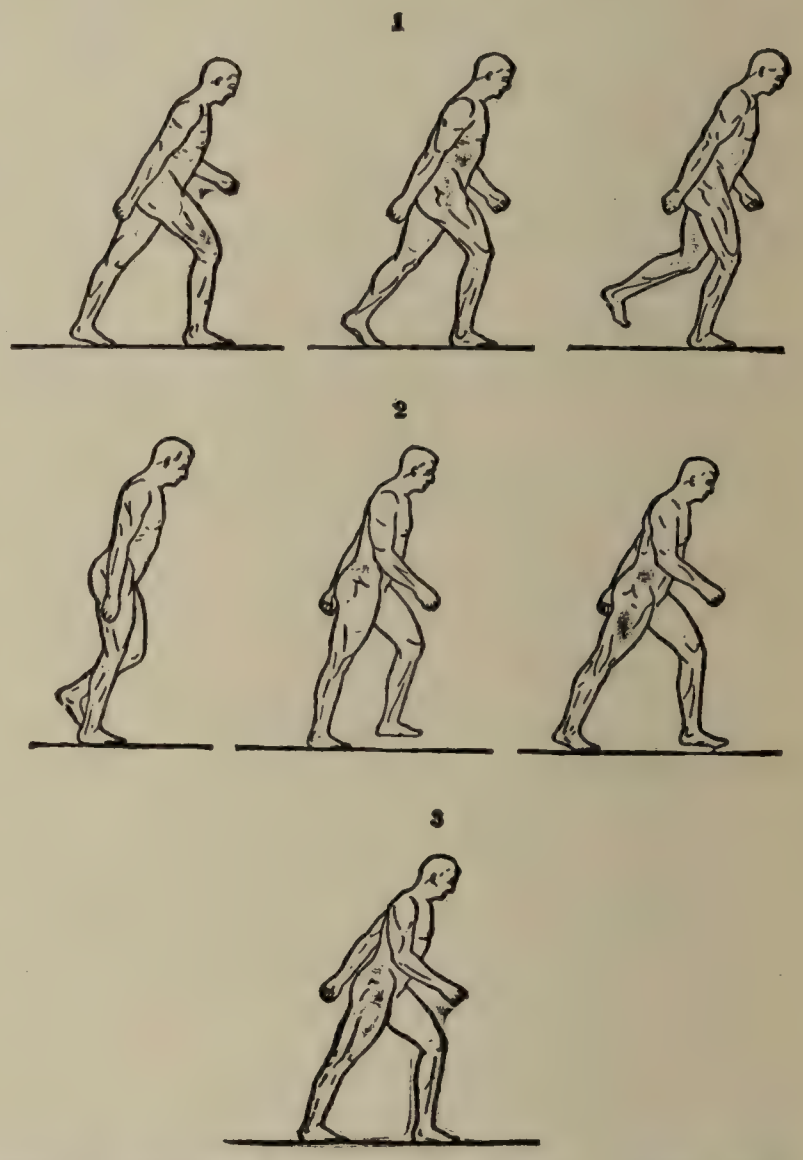


FIG. 6.—Flexion or Bent-knee Marching. (After Bradford.)

It is said that in this method a man's endurance depends entirely on the strength of his legs and not on his wind, since the lower extremities give out first. The shoes must be very loose, low and comfortable. Long distance pedestrians and soldiers, when tired, unconsciously fall into an imitation of this step, and so bring into action muscles which have not previously been used in ordinary locomotion. The ability to perform rapid and long marches without the expenditure of an undue amount of energy is a matter which concerns not only the sanitarian, but the tactician. The science of war has been defined as "getting there first with the most men," and this definition was never so applicable as it is to-day. The only objection to this step is that it lacks that rigidity and precision which is supposed to mark the soldier; but questions of sentiment cannot be permitted to outweigh those of practical utility. A thorough trial of flexion marching should be made in our service.

The length of the natural step varies with the height of the individual, and, according to Cortial, the proper step of the soldier on the march should not exceed six-sevenths of the height of his limbs. Since the marching step is assumed to be based on the average height and is somewhat in excess of the length of the natural step of the smaller men, it is always advisable to let troops take their own step on long marches, for experience amply demonstrates that many men can more easily increase the

number of their steps than they can their length. Should weights be carried the steps must necessarily be shorter, since the length of the step depends on the height to which the body is raised above the ground—a condition against which a heavy burden is constantly operating.

In the army of the United States the quick or marching step is 30 inches, measured from heel to heel, and the rate is 120 per minute. In double time the step is 36 inches and the cadence 180 per minute. The short step, quick time, measures 15 inches, and the short step, double time, measures 18 inches.

The marching step of various foreign armies, reduced to inches, is as follows:

In the German army the length is 31.2 inches, and the rate 112–114 per minute. The foot is brought down flat and with considerable emphasis, a method unnecessarily fatiguing and wasteful of energy. The German double quick step has a length of 39.4 inches and a cadence of 165–170 per minute. The step of the English army has a length of 30 inches and a rate of 112 per minute. In the French army the length of the step is 29.5 inches. The cadence at the beginning of the march is 120, and the same during the last half hour of the journey. After the march is well established the rate is accelerated to 125 or even 135 per minute. According to Laveran, the length of the marching step in the Austrian, Belgian, Swiss, Swedish and Italian armies is 29.5 inches. In the Russian army the cadence is 120 per minute, but the length of the step is only 28 inches. This is extremely short when compared with the marching step adopted by other countries, but appears to be easy and comfortable for troops. The Russian soldier, according to Tonnochy, throws his weight in both standing and marching more on the heel than the sole of the foot.

From a large number of elaborate experiments Marey concluded that for a man of average height (which he set at $65\frac{3}{4}$ inches) the length of the natural step was 31.7 inches and the cadence 120 per minute. If the same man carried a burden of forty-five pounds the length of the step was reduced several tenths of an inch. In experiments on a man untrained in marching he obtained the following results:

Number of steps per minute.	Length of pace, in inches.	Number of steps per minute.	Length of pace, in inches.	Number of steps per minute.	Length of pace, in inches.
110	28.89	130	32.48	150	33.66
120	31.72	140	32.79	160	33.26

This shows that there is no value in increasing the cadence beyond 150 per minute; since what is gained in number, at the cost of increase of fatigue, is lost in the diminution in the length of the step. The above results would seem to show clearly the artificial nature of the military step of 30 inches as adopted in our own and some foreign armies, particularly since our soldiers are of greater average height, and vindicates the action of the Germans in selecting a step of 31.2 inches for their march on campaign.

Unless guided by the will, the two steps are of unequal length, the

step with the right foot being somewhat longer than the left. With the eyes closed or in darkness it is impossible to proceed in a straight line for any distance, a deviation toward the left being noted.

In double time the distance traversed per minute is about one hundred and seventy-five yards, which rate, if prolonged, would mean the covering of six miles during the hour. As a matter of fact the double time can scarcely be considered as a marching step, since it should be—and is—but rarely employed, and then only for very brief periods. A running step, in spite of all previous training, is quickly exhausting to the soldier, and infantry can rarely be justifiably brought into action under such conditions.

Work Done on the March.—The march should be considered as labor performed in addition to the daily routine of camp or garrison and not at all as the only drain upon the energies of the soldier. Still, it is of value to know the amount of work done by the soldier on the march, and this knowledge has been supplied by recent investigation. According

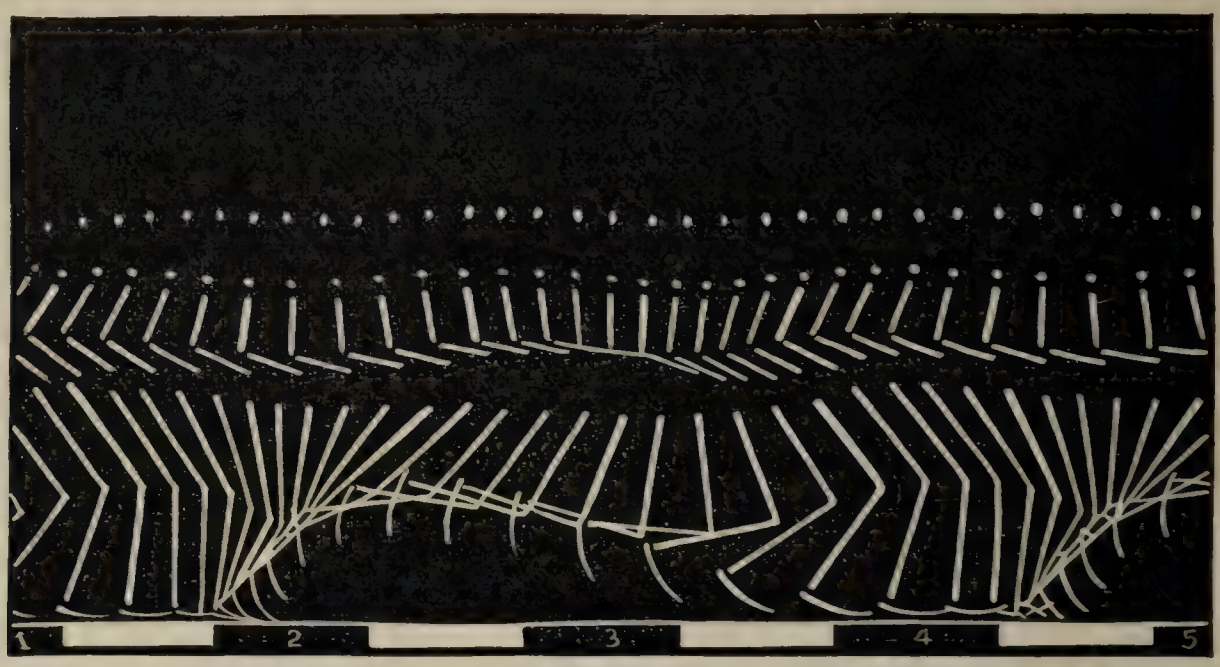


FIG. 7.—Positions of the Extremities of the Soldier During "Double Time." Photographs taken at the rate of sixty per second. (After Marey.)

to Rubner, the amount of work performed in ordinary walking, expressed in kilogram-meters, may be calculated according to the formula $0.071 \times W\ N$, where the number 0.071 = the height of the step, W = the body weight, and N = the number of steps taken. For the French soldier weighing 64 kgm. (141 lb.), Marey calculated that the expenditure of muscular energy required for each step, the cadence of the march being 120 per minute, was 12 kilogram-meters (1 kilogram-meter being equal to 7.2 foot-pounds). In double time, with a cadence of 180 per minute, the work done with each step was equal to 15.8 kilogram-meters; 0.3 kilogram-meters being due to the movement of the limbs, 8.0 in the vertical movement of the body and 7.5 in the horizontal translation of the latter. The expenditure of labor in passing over a flat surface varies with the rate of motion, and, according to Marey's experiments, ranged from 25 kilogram-meters per second of time to 74 kilogram-meters for the same period.

According to Notter and Firth, Coustan and others, the average daily work of the ordinary laborer is from 350 to 400 foot-tons, or about one-sixth or seventh the force theoretically obtainable from the food taken by the individual. Walking on a level surface at the rate of three miles per hour

is equivalent to raising one-twentieth of the combined weight of the walker and his burden through the distance passed over. For a soldier weighing 160 lb. and carrying a burden of 60 lb., a march of ten miles over flat country amounts to 259.30 foot-tons, or what would be a rather small daily expenditure of energy for the civilian laborer. On the other hand, a march of 20 miles with a weight of 60 lb. is alone a very hard day's work for the soldier, without taking into consideration the labor necessarily involved in making and breaking camp and the other laborious duties incident to the field, and such severe labor could not long be continued without injurious effects. If the ground be not level or the weight badly adjusted the expenditure of energy becomes greater, as is also the case if it be done in a shorter time. Velocity is also an important factor in determining the strain on the heart and lungs. For a soldier weighing 160 lb. to march a distance equaling 300 foot-tons in work done, would mean a journey of 16.3 miles at the rate of three miles per hour. Theoretically, as in practice, if the burden be advantageously arranged and the rate of march not too great, the soldier should be able to easily accomplish a per diem of 12 miles with an occasional rest; but a daily march of 20 miles, with full equipment, would not be possible for any great length of time. As a matter of fact, however, if very rapid or very long marches are required, the troops are usually sent out in light marching order, with the equipment reduced to the minimum; or they may later bring the labor within their powers of endurance by discarding portions of their equipment en route.

Position on the March.—Since marching in the rear of the column is comparatively much more fatiguing and disagreeable, each minor organization should, in its daily turn, lead within its next higher command—the same rule holding good for regiments, brigades, and divisions; but newly raised organizations, in marching, should preferably be placed at the head of the column, as they march better in this position, and in case of a skirmish behave better from the knowledge of having the support of seasoned troops.

It may be laid down as a general rule that infantry, on the march, should preserve a wide front and as open a formation as may be practicable, in order to avoid the deleterious effects of crowd-poisoning. In marching in dust, close order becomes particularly harassing to infantry, although the reverse is true in regard to cavalry. Infantry should never march with cavalry or artillery, and if a meeting becomes at times unavoidable it is well to move infantry off the road until other troops have passed.

Time.—Except in cold weather the early morning is far preferable for marching. The men are fresh, the air is cool, the heat of the sun is not burdensome and the men appear to be less fatigued by their exertion. But for crossing a malarious country the time selected should be the forenoon in the temperate climates and afternoon in the tropics, since the danger of malarial infection is much greater in the early morning before the heat of the sun becomes powerful.

Rapidity.—The rate of speed and individual ease with which troops march depends largely upon the size of the command. An ordinary day's march will be done in six hours by a regiment, while a division will need eight hours for the same distance. An army corps will require ten or

more hours to complete its day's march—this being largely due to the delays and accidents of the march, which are proportionately increased in the case of large bodies of men. On the march, barring halts, a brigade moves its own length in about fifteen minutes.

If no obstacles are to be overcome or especially unfavorable conditions of roads or weather are encountered, the ordinary rate of advance of an infantry column is about two and one-half miles per hour, including the halts necessary to bring the command to its destination in an effective condition and without stragglers. A day's march of fifteen miles is usually accomplished in about six hours. In large commands the rate of march of leading regiments should be carefully controlled, erring if anything on the side of slowness. The mounted officer of infantry, setting the pace for his command, should realize the limited capacity of foot troops. If a mixed column be necessary, the rate of march of the infantry must control the speed of the whole.

Marches should begin and end slowly. The French have an excellent custom of reducing the rate of march during the last half hour in order to avoid bringing the command into camp in too heated a condition.

Length.—As to the length of a march any definite rules are impossible, since marching is necessarily largely influenced by the conditions of weather, roads and military necessity.

Small groups of individuals, lightly burdened, can march very rapidly; and military marches appear to be but short to the trained and unencumbered pedestrian in civil life, he not stopping to consider the fact that work done by one is represented by weight carried plus distance marched, while in the other the same expenditure of energy is applied wholly to the gaining of distance. Further, the soldier cannot govern his own actions and must be considered merely as an individual unit of the moving army. His position in the ranks is fixed and must be constantly maintained in order to avoid interference with the space and movements of others. As this applies to the soldier so does it also to the company, regiment or brigade. On the march the soldier is warmly clad for such severe exercise, is unable to stop at the first promptings of fatigue and is compelled to accomplish a certain per diem of locomotion. The weak must keep up with the strong, the man of short stride with the one of long, and the very regularity of the step, when prolonged, tends to make it wearisome and exhausting. It must be remembered also, in computing the length of the march, that the soldier's duties do not end upon his arrival at the camping ground, and that he must prepare his lodgment, procure wood and water, perhaps go on guard, and perform a number of small tasks that are a considerable additional tax upon his energies. As expressed by Smart, the severity of the march must be measured not so much by the number of miles traversed as by the number of hours elapsing between the breaking of camp in one position and its establishment in another. It is a generally admitted principle that for a complete rest after a sustained effort, such as a long march, at least twelve hours in the twenty-four are necessary for both man and horse. Deducting from the remainder an interval of three or four hours for preparation for the march and for duties at the close, there will ordinarily remain for actual marching an interval of five to seven and one-half hours.

A long hard march at the outset may defeat the object of the journey by breaking down a large number of men and rendering them unfit for further marching; and hence, at the beginning of an extended march, unless the necessity be urgent, the distance traversed should be short. This affords an opportunity to the men to become gradually accustomed to the new conditions and the carriage of the equipment. The day's march may subsequently be increased until at the end of a week or ten days the maximum is reached; but in general, when a great distance is to be traversed, the daily marches should always be short rather than long.

In the United States a fair day's march for infantry, under usual conditions, is considered to be from fifteen to sixteen miles, or slightly higher than the average in European armies. On long marches or in campaign, the daily march of the English soldier is about twelve miles, occasionally as much as eighteen or twenty. In the march from Cabul to Candahar the expedition, comprising ten thousand men, eight thousand native followers and eleven thousand animals, averaged over sixteen miles daily for twenty-three days. The longest day's march was twenty-one miles. In the French army the average daily march in campaign is twelve and one-half to fifteen miles. General Lewal considered that a continued march, averaging twelve and one-half miles daily and carrying a equipment weighing forty-five pounds, was an excellent result in campaign. Spanish infantry, said to have no superiors as marchers, regard a march of fifteen miles, under usual conditions, as a fair day's work. In the German army the daily average is fourteen miles, with a halt every fourth day; but, according to Aitken, the Eighteenth (Prussian) Division, in 1870, marched two hundred and sixty miles in nine days in October, and fifty-four miles on December 16th and 17th, heavily equipped and over bad roads. According to Grodekoff, in 1896 a force of about three thousand Russians made a continuous march of three thousand miles in eastern Siberia, averaging about fourteen miles a day for a large part of the distance. On the entire journey it was found necessary to leave behind only four officers and twenty-nine men, and on arrival the command was in good condition and excellent spirits.

It appears to be a well-demonstrated fact that good infantry will, in continuous march or long campaign, wear out and out-march cavalry; but a greater average than fifteen miles daily is rarely achieved, unless by small bodies of men and for short periods. In the case of the soldier, other conditions being equal, weight carried and rate of march must be considered correlative. Beyond the mean established by long experience any attempt at increase in the one must be accompanied by a corresponding diminution of the other, or exhaustion quickly supervenes.

Meteorological Conditions.—No forethought can guard against marked changes in the weather, and continued marching in long periods of excessive wet, great cold or heat may frequently be more destructive to the efficiency of a command than the results of actual fighting, which at most is of short duration. As a general rule, troops should not be marched in rainy weather, since wet clothing is always to be considered a potent factor in reducing the vital resistance of the soldier and in predisposing to the occurrence of disease. Still, while actually exercising but little injury appears to be done to a moving command, and bad effects are

largely to be attributed to the surface chilling resulting from the frequent failure to change damp clothing on arrival at camp. In marching during wet weather the camping ground should be reached by noon, so that troops may be able to shelter themselves, collect fuel for fires, don the change of clothing carried in the equipment and dry their wet garments before nightfall—proper attention doing much to modify the untoward effects of exposure.

The length of the march is largely affected by meteorological conditions. As the barometric pressure diminishes so does the oxygenation of the blood, and hence also the vital forces of the organism. If such pressure be greatly reduced, as in the case of considerable elevation, the condition known as "mountain sickness" supervenes; but as usually observed in soldiers, the effects of rarefaction of the atmosphere are manifested only by hurried and difficult breathing. Temperature exerts a powerful influence on the march. If it be elevated the body is enervated, the muscular system is relaxed and the loss of fluid, through copious perspiration, interferes with the systemic equilibrium. Low temperature, on the contrary, has a strong tonic effect and stimulates to arduous exertion. Humidity, fog and rain render muscular movement and the evaporation of perspiration less free, increase the discomfort of the soldier and therefore by so much impair his efficiency and power. Snow and rain considerably diminish the length and rapidity of the march, especially if the snow-fall amounts to several inches or if the mud produced be deep or tenacious. The moisture absorbed by the clothing and equipment also adds much to the weight to be carried. In dry weather the dust raised by a marching column may become almost insupportable and do much to impair its energies. Head winds greatly impede marching, sometimes to the extent of diminishing the day's march by one-fourth.

Terrain.—The soldier is unable to select his own ground for marching, but must maintain his place in the ranks and his rate of speed irrespective of obstacles. Unless the ground be frozen he marches in the dust or mud created by the regiments which have preceded him; the discomfort and restriction of respiration caused by one, and the increased fatigue resulting from the other, being strong factors in the exhaustion of his energies and the curtailing of his capabilities. If the road be rough the foot is insecurely placed; if sandy, it sinks; if muddy or icy, it slips; if stony, it is liable to hurt or bruise—and all result in the increase of fatigue of the marcher, especially since he is obliged continually to modify his movements according to the nature of the surface and to keep his attention fixed upon the ground in front of him. On the other hand, marches over a smooth, gently rolling country are easier for troops than those made on a level, sandy surface; since muscles used in locomotion are rested by variety of action as well as by absolute inaction. It is in conformation with this principle that the tired couriers of the Orient walk backward to rest themselves and avoid the loss of time on the way. Whenever possible the movement of troops should occur parallel to the road and the latter be reserved for the use of the wagon trains. This permits the wagons to arrive promptly at the camping grounds, and prevents the occurrence of a long, dispiriting wait, often in rain, heat, or snow. The extra labor in marching over a pathless and possibly broken country is more than neutralized by

the comfort and satisfaction which the prompt pitching of camp brings to tired soldiers.

Equipment.—Soldiers on the march still are, during campaign, loaded down like beasts of burden, in spite of the efforts constantly made in all countries to reduce the weight of the personal equipment. Seasoned troops, wise through experience, will, when in the field, reduce the weight of their equipment to the minimum. Newly-raised troops, on the contrary, always overload themselves at the outset; failing to appreciate the disproportionate amount of fatigue which the carriage of a few extra pounds entails on its bearer in the course of a long march and considering as necessities many articles which they later come to regard as purely superfluous luxuries. Until this latter desirable condition is reached, however, frequent inspections are required to eliminate all unnecessary and unauthorized articles. Raw troops, when tired and perhaps overburdened on the march, will often be inclined to discard necessary portions of the equipment which will be required for their future comfort and health, and due care must be taken to prevent any such action on their part.

Forced Marches.—Such marches are fortunately but rarely required. From their nature they are accomplished under conditions involving scanty food and insufficient sleep, which, combined with the unusual fatigue, operate to produce early elimination of the less physically vigorous or untrained individuals of the command. Since the object of the march is not so much to transport men a given distance as it is, while marching, to constantly preserve their efficiency and fighting condition, commanding officers should not willingly undertake forced marches, as the risk of breaking down new troops is too great to be incurred without careful deliberation. On concluding a forced march even the best and most seasoned troops are exhausted, and before being fit for further extended effort require rest and recuperation. Hence a temporary loss of efficiency and a diminution of the effective strength must be calculated in advance as being the price which is to be paid for the position secured.

Anything above eighteen or twenty miles is practically a forced march, unless the conditions of the weather, temperature and terrain are extremely favorable. In Mexico, a French column is said to have travelled thirty miles in five hours at night, rested one hour and then marched nine miles further. According to Thomas, the grenadiers of Oudinot, in 1805, pursued the corps of Werneck for three consecutive days, the daily marches being thirty, forty and fifty miles respectively.

Three regiments of British infantry, in July, 1809, marched sixty-two miles in twenty-six consecutive hours, carrying arms, ammunition and packs—in all, a weight of between fifty and sixty pounds. This march implied an expenditure of energy equal to about six hundred foot-tons. One of these same regiments, during the Indian mutiny, marched forty-two miles in twenty hours, and on the following morning marched ten miles and engaged the mutineers. But marches of such character may be said practically to exceed the powers of any large military force under normal conditions.

In a forced march, after four hours, the column should be halted for an hour, during which time the men should, if water be at hand and the weather permit, wash the face, hands, neck and feet; but discrimination

as to the duration of the halt must be employed, since the men stiffen up if prolonged rests are permitted. A light lunch should preferably be issued at such a halt. Following a forced march a rest of a day will usually be necessary. Hence such a special effort, besides impairing the efficiency of the force, actually gains nothing in distance in a long journey.

Night Marches.—Marches at night are rarely necessary. Except under the stress of some imperative military necessity, the loss of sleep and general discomfort occasioned by such marches may be considered to far outweigh the ordinary advantages to be gained thereby. Many soldiers are unable to sleep as well during the day-time as during the darkness of the night, and for these such marches practically destroy all rest. A single night march is not an economy of time, since troops are required to rest the day before as well as the day after the effort. Under an attempt to continue such marching, troops may be expected to break down and an increase in sickness is the invariable result. This was well shown in a recent instance in which, of two French brigades arriving at the same depot, it was stated that the one made prolonged marches partly by night, while the marches of the other were short and slow and always by day. The result, as furnished by the hospital records, was as follows:

MARCHING BY LONG STAGES, PARTLY BY NIGHT.

Regiment.	Days of sickness.
2nd.	60.
4th.	41.
6th (1st Battalion).	43.

MARCHING BY SHORT STAGES, ALWAYS BY DAY.

Regiment.	Days of sickness.
1st.	32.
6th (2nd and 3rd Battalions).	14.
12th.	19.
3rd Chasseurs.	23.

Thus those who made long marches, partly by night, lost twice as much time by sickness as those who made short marches always by day, a significant commentary on the hygiene of exercise.

Unless the night be very clear or bright, some attempt at the illumination of the route should be attempted by means of lanterns or torches. Night-marching in mountains or rough country is particularly dangerous and fatiguing, and is always difficult. Despite the utmost caution of the soldier he is constantly stumbling, through miscalculation of distance in the deceiving light, and injuring his feet through contact with stones and surface inequalities. Drowsy, out of sorts and tired, he has not the mental stimulus to exertion which the constantly changing scenery of the day march affords.

Delays.—To avoid fatiguing delays in starting, the careful regulation of the march is necessary and each organization must be required to arrive at the designated point at the proper time. Having once started on the journey, troops should always be required to continue the march steadily

and without hesitation, even when minor obstacles, such as mud or pools of water, are encountered; for delay in advance is transmitted along the column and, the obstacle having been overcome, troops marching in the rear must increase their pace to regain their lost distance, or leading regiments must move slowly or halt to allow the rear to close up. Irregular progress is always particularly vexatious to marching troops. Time lost in waits of indefinite length probably cost more nervous strain and actual fatigue to troops than the same time spent in marching; since the uncertainty of the delay maintains the soldier in a condition of constant uneasiness, prevents the temporary removal of the equipment and destroys much of the benefit which might otherwise result from such a period of rest. Hence whenever occasional halts can be foreseen, they should be announced in the beginning and the whole column notified. Even in the case of accidental stops it may frequently be feasible to determine their probable duration, and to make such use of the delay as will best conserve the strength and temper of the command.

Rests.—In the prevention of exhaustion on the march from too continuous effort, the column should be halted at suitable intervals for periods of rest, and for this purpose frequent short halts during the march give more satisfactory results than by marching with fewer and longer delays en route. Their duration and frequency is thought by Pourvoirville and others to be determined more by the nature of the country traversed than by the length of the march, and to be directly influenced by the size of the command, small bodies of troops not requiring as frequent rests. Under ordinary circumstances, halts for infantry should occur every fifty minutes and last ten minutes; but in a mountainous country more frequent stops are necessary, and a breathing time of five minutes should be allowed every twenty-five minutes. For these halts the commanding officer should select situations not too hot, too wet nor too much exposed to the wind. Deep, sandy ravines or places where there is not free circulation of air are to be avoided.

A halt at the end of the first two miles enables the men to attend to the calls of nature and to adjust their equipment more satisfactorily. While resting, men should divest themselves of their packs and, if the ground be not too muddy, they should sit down. According to Woodhull, the French make use of a method of resting during short halts which saves time, prevents straggling, keeps the soldier off the ground and relieves his fatigue. In this method twenty or thirty men form a circle and each man sits on the knees of the man behind him. If perspiring freely, and exposed to a breeze, soldiers should move about sufficiently to avoid chilling. Overheated or exhausted troops should never lie on the damp ground. If a poncho or blanket is not available to protect against the ground dampness, the soldier should sit on a log or stone, or, failing in this, he should remain standing. It is well, if the march exceed a dozen miles, to halt for half an hour when half way—or about noon—for a light lunch; and for this purpose a shady, sheltered locality, close to an abundance of good water, should be chosen. In addition to those required for resting purposes, halts, in a large command, will now and then be necessary to enable the rear of the column to close up with the main body. If the command has been widely separated, the halt should be continued until

the rear organizations have been properly rested and are in condition to proceed on the journey.

Since it is well understood that tired troops cannot march successfully, it will scarcely be necessary to say that laborious field exercise of any kind should not usually be followed by a march without sufficient delay to allow of recuperation. In pressing the advantage of a victory such action is usually possible under the mental stimulus which is given by success; but that great risk exists of overtaxing the men under such conditions cannot be denied.

At the end of a march the feet should always be washed and dry stockings put on, and the men should take care not to expose themselves to the danger of chilling. If very warm, and they have no duties requiring physical exercise, extra clothing should be donned. Every eight or ten days, besides Sundays, an all-day halt will be required for rest and necessary repairs.

Use of Fluids.—In campaign in arid regions, under usual conditions, it is well to estimate the minimum daily allowance of water as not less than one gallon per man. This is merely the amount required for drinking and culinary purposes, and makes no provision for the maintenance of personal cleanliness. Much of this water may have to be carried in wagons.

Too free drinking of water on the march in temperate climates is inadvisable. Recruits are prone to drink as often during the day as they approach usable water, and such suffer greatly when restriction is necessitated by the absence of water en route, not marching with the same energy as men who drink in moderation. Soldiers who drink heartily before the start and then habitually refrain from drinking until the noonday lunch, or until camp be reached, soon learn to feel no discomfort from their failure to drink—and such a custom may be of the greatest service to them in campaign. While arbitrary control over the use of the canteen is unwise and impracticable, it is well to explain to the men the advantages of comparative abstinence. During a halt near a cold spring, overheated soldiers should be prevented from making too free use of the water to their own injury.

Canteens should habitually be carried filled. The future cannot always be foreseen, and even if not used on the march the contents may be needed if no water be found at the camp. While the supply should always be replenished at frequent intervals, especially in hot weather, great care must be taken to prevent the use of water from suspicious sources, and men should not be permitted to leave the ranks to fill canteens except by special authority. In foreign countries the civil authorities of towns, through which marching troops are to pass, are obliged to supply an abundance of fresh water of good quality for this purpose on the request of the commanding officer of the column.

At the halt or in camp a guard placed over the source of supply will prevent local pollution by men and animals. Dogs should not be allowed to range with a marching column when approaching water, since, if the weather be warm, they will invariably run ahead to cool themselves in the water. Stock should be watered, and men should wash their persons and clothing, at designated places below the point from which water for cooking and drinking purposes is drawn.

For use on the march, canteens may advantageously be filled with weak, unsweetened coffee, which appears to quench thirst better than pure water. The employment of tea, from its tendency to attack the metal of the canteen, is undesirable. The use of alcoholic liquors on the march is extremely injurious and provocative of sunstroke. If ever employed they should be used only toward the end of forced marches, to relieve exhaustion. The patronage of any neighboring saloons by the men, during halts, should be prohibited.

Tobacco chewing, and to a less degree smoking, is inadvisable on the march, since it increases thirst and causes an additional drain on the fluids of the body through the necessarily frequent expectoration.

The sensation of thirst may be largely prevented by carrying some small hard object in the mouth, as a twig or pebble, to excite the flow of the salivary glands and so moisten the fauces. The slow sipping of water is said to favor its absorption.

Straggling.—Nothing so much harasses troops as straggling on the line of march. Should a soldier find it necessary to fall out between halts for any purpose, special authority from his company commander should be obtained and his prompt return to his place required under pain of punishment, his piece being carried by another until his return. During a halt scattering should not be permitted, and the command under all circumstances should be kept well together and in hand. Straggling is an evil which directly impairs the military efficiency of a command, and, like all infractions of discipline, may be expected to exert an unfavorable effect upon the general health and morale. Its prevention depends upon careful determination and elimination of the sick, the encouragement and perhaps the assistance of the tired and the application of suitable measures to the lazy and undisciplined. The careful transportation of the sick will, with good troops, induce extra effort on the part of the latter; they believing that they will be well cared for should they become exhausted.

Convalescents are to be spared as much as possible on the march. Their equipment should, if possible, be carried with the baggage. Every precaution should be taken to prevent their becoming wet, since such exposure, combined with fatigue, will often return them to hospital. With due precautions they will be actually strengthened by not too arduous marching and will shortly be able to return to their full duties in the ranks.

Mouth-Breathing.—During the march, breathing through the mouth is to be avoided. This prevents the passage of unwarmed air or particles of dust into the lungs, with resulting possible irritation, and also diminishes the sensation of thirst and tendency toward breathlessness.

Mental Occupation.—To occupy the mind of the soldier on the march is an excellent way of preventing fatigue and weariness. Absolute silence is depressing to the men, and should not be required; but frequent talking is undesirable and is to be discouraged. At high altitudes or on dusty roads marching soldiers are instinctively silent.

Singing en route affords a pleasing mental occupation and does much to lessen the tedium of the march. Nevertheless, in the presence of fog, dust, inclement weather, or during the occurrence of epidemic influenza

or bronchial affections, general singing on the march would seem inadvisable. The Russians have recognized this fact to the extent of selecting beforehand certain soldiers to do the singing for their respective organizations during the journey. Military music is a diversion and mental stimulant and hence is a positive aid on the march. Its rhythm materially assists in imparting and maintaining the proper step and swing, this being especially true of full bands or the fife and drum. As marching music that of the trumpet is distinctly inferior.

Accidents of the March.—In the conduction of the march various conditions may operate to imperil the safety or impair the efficiency of the command. Notably in the first class may be mentioned the disastrous effects which may result from exposure to extreme heat or cold, which, since they depend more upon temperature and climate than upon the method in which the military march is conducted, receive attention elsewhere. The second class naturally includes such injuries to the individual which, though theoretically preventable and intrinsically of but slight importance, exert a serious and unfavorable influence upon the effective strength and mobility of marching troops.

Blisters and Excoriations.—Blisters and excoriations of the feet, in themselves of no importance, often require rest for their recovery. For this reason they possess a considerable interest from a military point of view, especially as they may rapidly render a large number of men unfit for military service and so diminish in large proportion the effective force at the beginning of campaign. Tourraine estimated that after several days' marching about one-fourth of an infantry command would present excoriations of the feet; while military statistics in general show that from twenty-five to thirty per cent. of troops in campaign, as a result of the first few days' marching, sustain more or less injury to the feet. In the Army of the Potomac whole brigades are said to have been temporarily disabled from this cause; and it has been estimated that in European armies an average loss of ten per cent. of the effective force, directly due to the hard marching of campaign, must be anticipated among unseasoned troops on taking the field. In the early part of the Franco-Prussian war, in the Tenth Army Corps, the constant ineffective from injury to the feet, as a result of marching, ranged from eight to ten per cent.; and it is said that at one time not less than thirty thousand German soldiers were, from this cause alone, unfit to perform field service. Such results are partly to be explained by the fact that socks or stockings, which are of great value in preventing chafing by the hard leather, are not issued to their troops by most European nations, and the soldier must either wrap his feet in small pieces of cloth, as a makeshift, or do without adequate protection. However, under the best circumstances and with all precautions, constant marching must be expected early to render a considerable proportion of an infantry command unfit for duty. It thus becomes evident that care with regard to the feet of the infantry soldier is well recompensed by his increased efficiency.

Blisters are naturally produced on those points which support the greatest pressure and friction, these being generally the heel and top of the metatarsal bones. The most painful and serious abrasions usually occur on the heel at the level of the insertion of the tendo Achillis.

These cause great suffering to the soldier and usually render his continuance on the march impossible. Blisters on the soles of the feet at once disable. In the production of the blister there is an elevation of the epidermis comparable to that which follows a burn of the first degree. Should the epidermal covering be torn off, the skin becomes inflamed and the discomfort of the individual considerably increased. Evacuation of the blister is best done by traversing it with a thread and allowing the oozing of its contents. The raised cuticle may then be greased, pressed into place and, if at night, lightly bandaged.

Ill-fitting shoes combine with uncleanliness of the feet to disable the marching soldier. Hence it is well to use in daily rotation the two pairs of shoes included in the equipment of the soldier and so prevent a constant pressure upon the same points. On the march the feet are, if practicable, to be kept dry, since continuous moisture softens and loosens the epidermis and favors the formation of blisters. Shoes, when wet, become heavy and rapidly lose their shape; while damp socks are liable to wrinkle and induce abrasions of the cuticle. The employment of soft, smooth, undarned socks, of good fit and excellent quality, will do much to prevent injury of the feet from marching.

Cleanliness of the feet on the march is a prime military necessity. Its importance is fully understood in European armies, and during campaign each German soldier is required by regulations to wash his feet within two hours after arrival at camp or cantonment. The ablution of the feet, at least once daily, is imperative; and an even more frequent cleaning is desirable during hard field service. Brief immersion in cold water after the daily march has a soothing effect and removes the sensation of burning and irritation; but prolonged soaking of the feet is inadvisable as softening the cuticle and so tending to promote its injury. If facilities for the complete washing of the feet are not at hand, a thorough wiping with a wet cloth, particularly of the toes, answers an excellent purpose in the removal of grease and dirt.

A large proportion of such soldiers as suffer from blisters and excoriations—perhaps one half—require medical attention and care, and should be encouraged to apply to the surgeon for relief; but such are not to be readily excused from the performance of full military duty. After the washing and drying of sore feet their careful greasing is advisable, particularly of painful localities, before the actual formation of blisters has occurred. For this purpose the fresh tallow of beef or mutton may be used, but the employment of rancid or salted fats is undesirable. According to Laveran, an excellent plan is to saturate a pair of cotton stockings with grease. If worn on the march only, and the feet be cleansed and fresh socks donned when camp is reached, a single pair of greased stockings will serve admirably for a number of days without washing. A popular method among United States soldiers is to thoroughly soap the foot before beginning the day's journey, thus diminishing friction from the stocking. For hardening the epidermis, foot baths of strong brine or alum solution will be found of advantage as will also the application of alcohol, either full strength or diluted one-half with water. For excoriations, the use of astringent ointments, having a basis of lead, zinc or tannin, are often of service. In the German army a two-per-cent. ointment of salicylic

acid, made up with mutton tallow, is much favored. An excellent procedure, used in the French and German armies, consists in covering the abrasions with wadding soaked in a ten per cent. solution of chromic acid. In the beginning of treatment a strength of five per cent. is often sufficient. Excessive sweating of the feet may be relieved by bathing in weak solutions of perchloride of iron or of potassium permanganate. Recently weak solutions of formaldehyde have been used for the same purpose. The use of finely pulverized alum, dusted into the stockings, is said by Simonton to diminish secretion and harden the epidermis. For similar purposes a foot powder is employed in the German army containing the following ingredients: Salicylic acid, 3 parts; starch, 10 parts; powdered talcum, 87 parts. Of this powder about 5 gm. are used daily by each individual. Hard corns, if troublesome, may be temporarily removed by scraping with a fragment of broken glass. In the prevention of injury to the feet by marching three factors must receive consideration: the elimination of soldiers with badly formed feet, the issue of a good quality and style of footwear, and the enforcement of cleanliness and such measures of prophylaxis as are above noted.

Both foot and mounted troops, particularly in hot weather, are liable to suffer from chafing of the groins and nates as a result of the wearing of ill-fitting, irritating and sweaty underclothing during the march. A knowledge of the cause of the injury suggests the remedy, and the same principles should be applied for this condition as have just been suggested with reference to the care of the feet of the soldier.

Pied Forcé.—The swelling of the feet, pain about the tarsal region and functional incapacity to some degree observed among large marching commands was long supposed to be due to a periostitis of traumatic origin. It remained for Boisson and Chapotot to demonstrate in 1899, from Roentgen-ray photographs taken of a considerable number of cases, that the condition is due to fracture of the diaphysis of a metatarsal bone, usually the second. According to these investigators the fracture is induced by the carriage of heavy weights for long distances over rough roads. The second metatarsal is usually injured on account of its length, slenderness, and proximity to the inner border of the foot. Fixed as it is at its tarsal extremity, under the condition of a lever of the second order, it is in just the position to be fractured. The condition is naturally rarely bilateral. Stout and roomy shoes, with all possible reduction in the weight of the equipment, will do much to prevent the occurrence of this accident.

Heart Strain.—A well-defined group of symptoms, for want of a more scientific designation known as "irritable heart of the soldier" or "heart strain," has received considerable attention from military and medical writers—in this country notably from Taylor and Da Costa.

These cardiac symptoms usually occur in young and untrained soldiers, especially when weakened by disease or privation, during the occurrence of forced marches and particularly in warm weather. The general symptoms may be indefinite, but the soldier usually complains of pain in the chest and inability to carry his equipment on the march without losing his breath. The pulse is weak, intermittent and dicrotic, and there is the general appearance of exhaustion. Often there is dizziness, which may occur at night. The condition is brought on by great exertion, particu-

larly in the absence of proper preliminary training, and especially in such cases as may be affected with latent cardiac weakness, not discoverable upon ordinary physical examination. Since restricted respiratory function must be looked upon as an important exciting cause of heart strain, its occurrence will be largely favored by the mechanical compression of the chest wall by tight clothing, belts and the weight and mode of carriage of the equipment. Examination of the heart reveals no valvular lesions, but dilatation of the cardiac chambers, often excessive, may be noted. The right ventricle is the one usually dilated because of its thinner walls, and the greater proportionate strain to which it is subjected. As a result of the examination of a body of soldiers who had marched a distance of fifty miles, Teissier, in 1894, noted that the apex of the heart was displaced outward, that its breadth was increased and that the venous circulation was impaired. The action of the heart was short and irregular and a well-defined cardiac murmur was present. The arterial pressure was considerably lowered. The action of the heart may be seriously impaired or even paralyzed through the stretching and separation of its muscular fibrillæ. Permanent and serious impairment of the cardiac function not rarely results, although the symptoms of heart strain may disappear as long as exertion is not required. A number of cases immediately fatal through cardiac paralysis have been noted, although the condition must be considered rather as chronic than acute.

According to Taylor, at the battle of Corinth, during the Civil War, of two companies which had engaged in a lively reconnaissance, one-fourth of the men returned in a state of complete exhaustion, while three soldiers had dropped from the ranks from cardiac syncope and were supposed to be dead. Even under the most favorable conditions, heart strain disqualifies the soldier for hard military service; for the same mode of life which originated the disease will operate even more powerfully for its return in the weakened organ.

Should a soldier on the march present the symptoms of this affection any tight clothing should be loosened, his equipment removed and he be furnished with wheel transportation. Continuance of exertion in such a case can only result in serious permanent injury to the individual. The prophylaxis of this condition depends upon the prompt discharge from the military service of all soldiers who, at any time, present signs of cardiac weakness. Marches are to be carefully regulated, lest too great exertion induce strain and dilatation of the healthy heart and so create a condition permanently destructive to the efficiency of the soldier.

Health.—A marching column is proverbially a healthy column and, barring footsoreness, usually shows a much smaller rate of sickness than when in camp. Daily marching, however, in connection with the concentrated food usually employed, has a tendency to lead men to neglect their bowels, in the production of constipation. It is of course desirable, in the remedying of this condition, that too strong catharsis be not produced while on the march.

As remarked by Woodhull, for the proper conduction of the march either ample personal experience or careful attention to theoretical detail is required.

CHAPTER IV.

WATER.

I.

QUANTITY, SOURCES, STORAGE AND SUPPLY.

Quantity.—The supply of a sufficient amount of wholesome water is a fundamental sanitary necessity. As a general rule, quantity of supply has a bearing on the health of troops chiefly through its relation to personal cleanliness. It may, however, under certain conditions, be so scanty as to exert a directly deleterious effect upon the organism of the soldier.

The determination of the quantity of water to be provided for troops depends to a considerable extent upon their manner of living and the presence or absence of an efficient system of drainage and sewerage. As far as the soldier is concerned, the results either of a limited supply of water, or of difficulty in removing water which has been used, are very similar. Hence an essential step, in securing the use of an abundance of water, is an adequate provision for its subsequent removal. Whatever the quantity of water which is to be allowed, the supply, considering the circumstances, should be liberal. There should be proper economy in use and avoidance of waste; but any error in supply had far better be on the side of excess. For troops in barracks a fair allowance is fifteen gallons per capita for all purposes except baths and water closets; of this amount about one and one-half gallons being required for drinking and cooking. A daily supply in garrison of five gallons is probably the minimum compatible with health, and with this quantity proper cleanliness of the person and surroundings cannot be maintained. Water closets require four to six gallons daily for efficient flushing, according to the pattern used; and in this particular instance a false economy in the use of water is most undesirable. A certain amount of water, when the post is sewered, about five gallons per capita, will advantageously be allowed to run to waste in each twenty-four hours in order to maintain due cleanliness of the sewer pipes. Where shower baths are used, an allowance of three or four gallons a head is sufficient for a daily bath. If the tub bath system is employed, the amount of water required for each bath is much greater—forty to fifty gallons—but such baths are less convenient and are probably taken less frequently. Taking all factors into consideration, together with the matter of unavoidable wastage, it is probable that a daily allowance of not less than thirty-five gallons will be to the best interests of the soldier. In the British army each adult is entitled by regulations to receive twenty gallons, and each child ten gallons, per diem. According to Viry, the minimum allowance in the French service is seven and one-half gallons to the foot soldier, nine gallons to the cavalryman, and twenty-

five gallons to each kitchen. In Germany, according to the same authority, the daily allowance is twelve and one-half gallons to each soldier. These amounts are obviously quite insufficient for the maintenance of the standard of cleanliness, as regards person and surroundings, obtaining in the army of the United States. In hot climates a much greater quantity is required for washing and bathing; and probably a supply of fifty gallons per diem, under such circumstances, should be regarded as the minimum.

At certain western stations in the arid belt, where the water supply from rainfall is never very great and is somewhat uncertain, the supply of water available may be, at certain periods, insufficient to meet demands for all purposes. Nearly all posts of this character, however, have been abandoned during the last few years.

For hospitals a much larger quantity of water must be provided than is required for barracks. Where possible the supply should be unlimited. There is necessarily much bathing and washing in such institutions, and with a considerable proportion of typhoid cases the average daily consumption, per capita, may readily reach two hundred and fifty gallons.

The minimum quantity of water ordinarily to be supplied during active campaign amounts to about two gallons daily, divided as follows: For drinking and cooking purposes, four and one-half quarts; for the maintenance of cleanliness, two and one-half quarts; unavoidable wastage, one quart During great emergency the matter of bodily cleanliness may be disregarded, and the amount of water for drinking and cooking purposes reduced to about three or four quarts—but such reduction must obviously be only temporary. During campaign in hot weather or in the tropics it is probable that a daily allowance of three gallons should be considered as the minimum compatible with a reasonable degree of comfort.

During a march the water supply is limited, consisting for each man of what can be carried in the canteen. No dependence can often be placed on the probability of replenishing the supply while en route, and hence the guides for use should be the water level in the canteen and the length of the day or journey, rather than the desires of the individual. Experience shows the capacity of the canteen, one quart, to be often insufficient during long marches in hot weather; but it is especially under these conditions that the overloading of the foot soldier by an additional burden is highly inadvisable. For mounted troops no such objection obtains, and hence for long marches in a hot and waterless country the carriage of an extra canteen by the cavalryman will usually be of advantage. In certain regions, water is so scarce that judicious management is required to forward troops over the route. Some camping stations may have enough for only one or two companies or regiments, and the command, if larger, must pass in detachments. Where the distance between the nearest supplies of water is too great to be marched without rest, a dry camp must be made at some suitable intervening point, as much water as possible being transported with the command.

For stationary camps the minimum quantity of water to be supplied each soldier, for all purposes, should be placed at about five gallons. If the quantity be more than ten gallons per capita its proper disposal, in the absence of sewers, may become a serious problem.

Horses require, as a daily minimum, six to eight gallons of water for drinking purposes, according to season and work, with an additional allowance of about three gallons for the maintenance of cleanliness. If a horse be given free access to water, he will take eight to ten gallons daily, and sometimes more, drinking from one and one-half to two gallons at a time. Mules and cattle drink slightly less than horses. In the expedition against Santiago, the official allowance of water for horses and mules was six gallons per capita, this appearing to be sufficient. In the British service the maximum allowance for each public animal is twenty gallons.

Where watering the streets of the camp or post is necessary, the dust may be laid by the use of two hundred and twenty-five gallons to each six hundred square yards of surface. In providing the amount of water required for this purpose, the probable number of dusty days, as well as the superficial space to be watered, should be taken into consideration.

Permanency.—In the establishment of a military post or standing camp, the importance of determining the permanence of the water supply is obvious. To this end any available evidence should be obtained; particularly with reference to the amount and period of rain, without which it is impossible to arrive at any safe conclusion. The country which forms the gathering-ground for the springs or rivers should be considered. If there be an extensive background of hills, the springs toward the foot of the hills will probably be permanent. In a flat country the permanency is doubtful unless there be evidence from the temperature of the spring that the water comes from some depth. In limestone regions, springs are often fed from subterranean reservoirs, caused by the gradual solution of the rocks by the water charged with carbonic acid, and such springs are very permanent. In the chalk districts there are few springs or streams, on account of the porosity of the soil, unless at points where the level is considerably below that of the country generally. The same may be said of the sandstone formations, both old and new; but deep wells in sandstone often yield largely, as the permeable rocks form a vast reservoir. In the granitic and trap districts small streams are liable to great variations, unless fed from lakes; springs are more permanent when they exist. Much also depends upon the quantity and character of the vegetation of the watershed. Where the country is well wooded, the trees, undergrowth and especially the dead vegetable matter covering the ground do much to retain moisture and render its percolation to lower levels a gradual process. The roots of vegetation greatly promote absorption of the rainfall. Further, in northern climates, heavy vegetation greatly delays the melting of snow in the spring, and thus assists in creating a supply of water for the dryer summer months. If the watershed be cleared of timber and brushwood the volume of existing watercourses is materially altered, a steady supply at all seasons being replaced by alternating periods of freshet and drought. This is a matter of particular importance in those regions, as in the arid belt of the west, where the annual precipitation is small, and is limited to certain seasons. Several military posts established on what had previously been perennial streams of ample volume have had their existence threatened as a result of the greatly decreased water supply which followed the mistaken policy of permitting

indiscriminate felling of timber and unchecked forest fires. In one instance the removal of a large number of beaver dams allowed the rapid escape of waters during the spring floods, none being retained to trickle down into the reservoir of the post during the dry season.

In determining the sufficiency of a water supply for a proposed post, the decision should be obviously based upon estimates made during the period of least flow, and preferably for the dryest year.

Rain Water.—Rain water approaches nearer to purity than any other kind of natural water, receiving only such contamination as may be derived from the atmosphere. This water is highly aërated, containing a greater proportion of oxygen as regards nitrogen than does atmospheric air, through the readiness with which the former gas passes into aqueous solution. Through its purity and aëration it is both healthful and palatable; and when the supply from the surface or ground water is poor the use of rain water is desirable. Through the absence of earthy salts, rain water is very soft and admirably suited for purposes of cleanliness and cooking. Where proper arrangements for its storage in tanks or cisterns can be made, the use of such water is calculated to limit the diseases ordinarily transmitted by water. This is especially the case in time of epidemics, when infectious material so frequently finds its way into the general source of water supply for the community. The uncertainty of the rainfall from year to year, the length of the dry season in many localities and the large size of the cisterns which are then required are the disadvantages of using water from this source. The use of cisterns as a source of water supply for troops is still continued at Fort Stevens, Fort St. Philip, Jackson Barracks, and other stations. At many small artillery posts no other method of supply is available, and it has happened, in periods of drought, that water has had to be brought in by boat and pumped into the cisterns. At certain western stations, notably old Fort Sisseton, established for military reasons away from an abundant water supply, cisterns were employed for the purpose of supplementing the scanty and uncertain local supply.

In determining the amount of water available from the rainfall, the precipitation during the period to be considered and the area of the receiving surface must be known. The former can be determined only by a rain gauge; the latter may be measured. To calculate the receiving surface of a roof, the slope should not be taken into account, but merely the flat surface actually covered by the roof. The external dimensions of the building, when multiplied together, give a superficies slightly less than the area of the roof, which also includes a certain space due to the projection of the eaves. For military purposes it is sufficient to multiply the area of the receiving surface by half the rainfall in inches, the result being in gallons. The error by this calculation is only about four per cent.

In estimating the size of the cistern required, besides the amount of water to be used daily, the least, the greatest and the average annual rainfall should be known; together with the period when it falls, and the duration of the rainless season, when no replenishment of the supply, from time to time, may be expected. The average of twenty years, less one-third, gives very accurately the amount of rain in the driest year; and the same average, plus one-third, gives very nearly the amount in the wettest

year. The average of the three driest years in twenty is a safe basis for computation. It may be assumed that about six-tenths of the rainfall is ordinarily available for storage.

For the construction of large cisterns the best material is brick or stone, thoroughly cemented inside. Common mortar should not be allowed to come in contact with the contained water, since lime is readily taken up and the water becomes hard. In the construction of small cisterns, slate may be advantageously employed, but is somewhat liable to leakage. For tanks above ground, galvanized iron is much used. Where common boiler iron is employed the metal corrodes and colors the water; in such instances the application of an interior coating of cement or asphaltum paint is advisable. Wooden tanks should not be used, especially in hot climates. Where there is great fluctuation in the water level of a wooden cistern, organic development is liable to occur and the tank itself readily falls out of repair.

Receptacles for the storage of rain water should always be well covered to prevent pollution of their contents, and be thoroughly ventilated if of

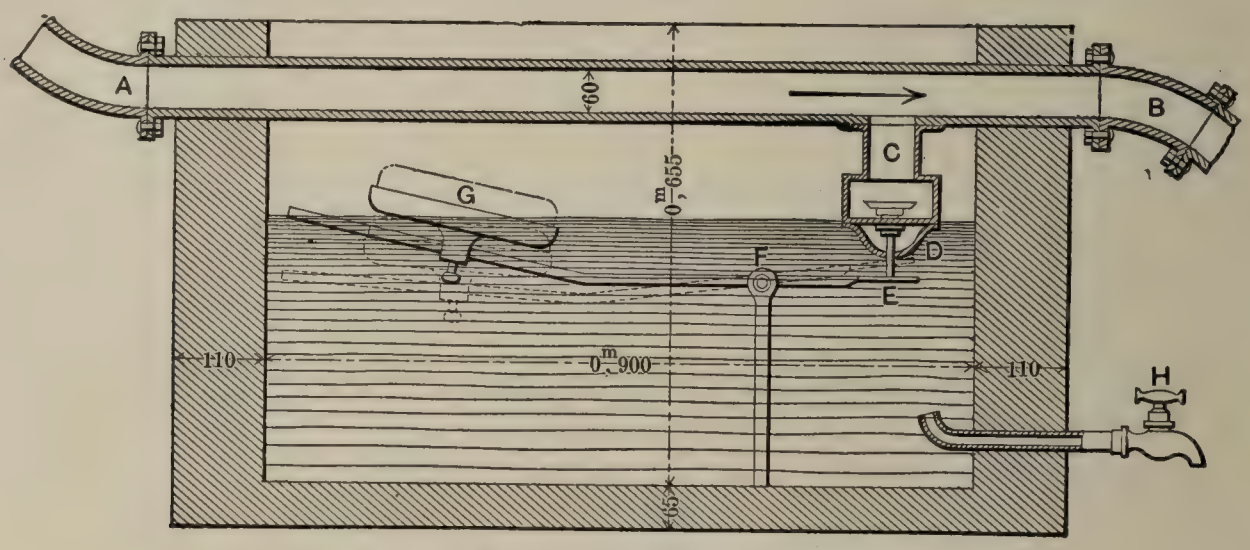


FIG. 8.—Separating Tank for Rain Water.

any great size. Light should be excluded to prevent the growth of vegetation. Care should always be taken that there is no leakage into them, a contingency impossible if the cisterns be above ground. Where the latter plan is adopted, a large iron tank, on a suitable platform, is perhaps the best reservoir; bearing in mind the fact that in addition to the weight of the tank each gallon of water stored at a temperature of 60° F. will weigh about ten pounds. It is important that the overflow pipe be not directly connected with a sewer—thus allowing the absorption of sewer gases—but be made to discharge above ground over a trapped grating.

The amount of dust collected on a roof during periods of prolonged drought is by no means inconsiderable; and to this may be added organic matter in the form of leaves, mossy growths and the excrement of birds. Such materials impart a peculiarly unpleasant taste to cistern water, as well as being a possible agent in the production of disease, and hence the separation and rejection of the first portion of the rainfall is desirable. This is readily accomplished by several forms of automatic apparatus, the most simple of which is a receiving tank operating a float, the latter moving a plunger in a divided pipe so as to divert the stream of water from one pipe through the other after the tank is filled. According to Viry, it

has been determined that a rainfall of one liter on each two square meters of collecting space is ordinarily sufficient for securing cleanliness, and hence the dimensions of the separating tank may be calculated accordingly. In the absence of automatic apparatus of this character, the rejection of the roof washings may be less conveniently accomplished by inserting a joint in the conductor, which, when in place, leads the water into a cistern, but when turned runs it to waste.

It is always advisable to filter rain-water before storage. This is preferably accomplished according to the plan shown in the accompanying illustration. Where this cannot be done, the cistern may be divided into two compartments by a tight partition having several openings near the bottom. In one compartment is placed the filtering material, usually composed of three or four feet of clean, coarse sand. The roof leader empties into this side, while the filtered water is drawn from the other compartment. Where the cistern is so large that it cannot well be covered, a second smaller tank, capable of holding a few days' supply, might be

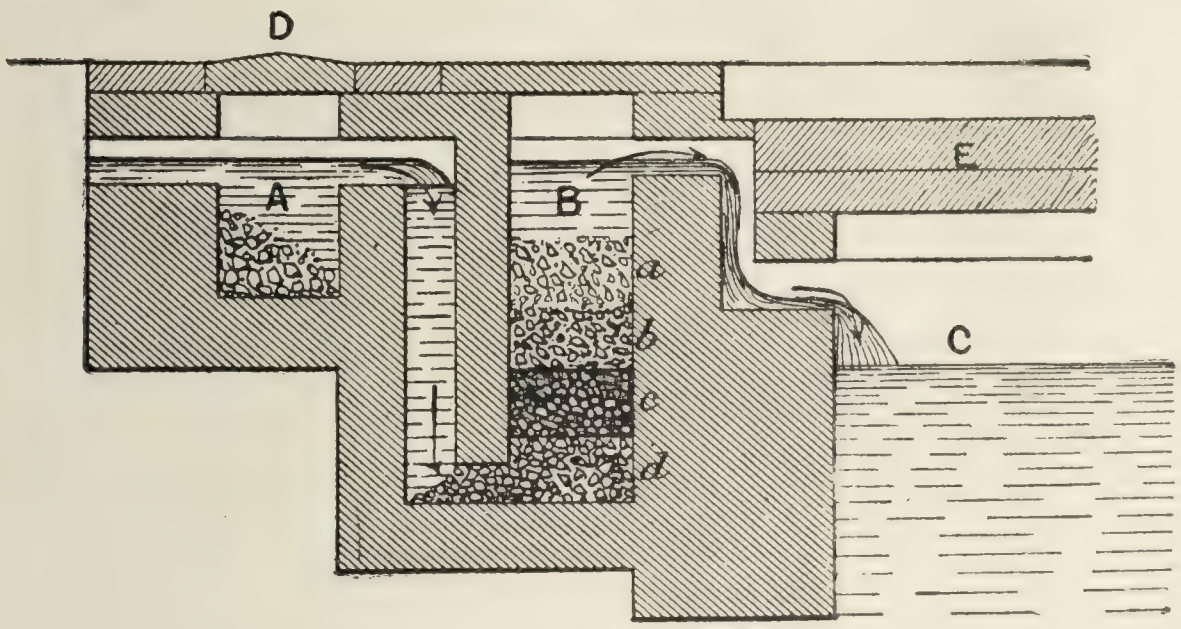


FIG. 9.—Method of Filtering Rain Water. (After Parkes.)

provided and fitted with a filter through which water from the larger reservoir could be led as required.

Cisterns should be periodically inspected and cleaned. This is a matter of great importance; since there are recorded many instances of the grossest kind of pollution of cistern water, arising from ignorant neglect of what would seem very evident and simple precautions.

Surface Waters.—The water of large lakes is usually excellent and free from any great impurity. The mineral matter present, in both nature and amount, largely depends upon the character of the soil over which the water rests; but ordinarily, with the exception of lime salts, the quantity of dissolved mineral matter is small. The organic material present is chiefly of vegetable and not animal origin. In small surface ponds the water is frequently unwholesome from the high degree of vegetable impregnation and is largely exposed to animal contamination, while concentration by evaporation may render such water more deleterious. Water from such sources should ordinarily be regarded as unsafe.

Marsh water should be unhesitatingly rejected as a source of supply for troops, being rich in organic matter and hence in the lower forms of

animal life. It undoubtedly has a strong influence on the prevalence of dysentery, and is presumably a medium by which the causative agent of malaria finds its way into the organism.

Fed from a variety of sources and directly influenced by season and meteorological conditions, river water is usually complex in its constitution. Sometimes river water is almost as pure as rain water; or it may, on the other hand, contain a high proportion of mineral matter, or be foul from pollution by sewage or other impurities. An excellent index of the potability of river water is ordinarily given by the character of the country through which it flows, and the density of the population along its banks. In general, river water is both good and palatable; but streams receiving the sewage of towns or undergoing pollution from the encampment of large bodies of troops along their banks are dangerous sources of supply for many miles below the point of contamination. It is true that surface, and especially running, water undergoes self-purification; but the factors bringing about this end are dependent upon such variable conditions that it is scarcely possible to determine both rapidly and accurately the point at which such water again becomes suitable for human consumption. As far as the military sanitarian is concerned, it is probably safe to consider all running water receiving a proportionately large amount of organic contamination within the distance of one day's march for foot troops, estimated on the meander line of the stream, as at least suspicious.

This process of self-purification of surface waters varies greatly in rapidity, according, as stated above, to the presence or absence of varying factors. Solid sewage is soon deposited on the bed of the stream or becomes food for fish and the lower forms of organic life. Dissolved or particulate organic material, in a rapid current, breaks up quickly under the influence of the large amount of oxygen held in solution in such highly aërated waters, and the same factor is inimical to the development and existence of pathogenic micro-organisms. The latter also are probably destroyed by the hard particles of sand or grit held in suspension in a turbid water and with which they constantly come in violent contact, while the sedimentation of such earthy particles in still waters results also in the mechanical entanglement and deposition of a considerable proportion of the germ life. Kruger, in investigating the influence of precipitating mud in hastening the fall of suspended bacteria, and using one-half gramme of fine sterilized potter's clay in each liter of water, obtained the following counts of bacteria in each cubic centimeter, the water being maintained at 55° F.:

	Water with Clay.			Control Water Containing No Clay.		
	Top.	Middle.	Bottom.	Top.	Middle.	Bottom.
After standing two hours	575	887	33,495	5,340	6,110	5,480
After standing twenty hours ..	521	155	43,595	5,960	6,710	6,210
After standing fifty hours.....	6,933	6,190	66,350	7,230	5,987	6,924

In addition, the solar rays are powerful factors in the destruction of bacteria, the blue and violet rays being particularly germicidal. This influence of the solar rays has been ingeniously shown by Buchner, who

exposed a Petri dish, thickly sowed with the typhoid bacillus, to the sunlight; certain parts of the dish being shaded by letters of the alphabet cut out of black paper. After six hours' exposure the dish was removed and placed in an incubator, subsequent examination showing no development of bacteria on the parts exposed to the sunlight, while a strikingly luxuriant and well-defined growth occurred on the parts shaded by the black letters. Buchner also found that the germicidal effect of sunlight was pronounced even at considerable depths of water, plates of nutrient gelatin inoculated with the typhoid bacillus being sterilized by exposure during four and one-half hours at a depth of five feet three inches in lake water. Similar plates, however, exposed at a distance of ten feet below the surface, exhibited but little diminution of vitality. It is obvious that the degree of turbidity in a water markedly influences the action of sunlight on the contained micro-organisms.

Where a considerable body of troops is to be encamped or stationed on a small watercourse, it is often important that the sufficiency of supply

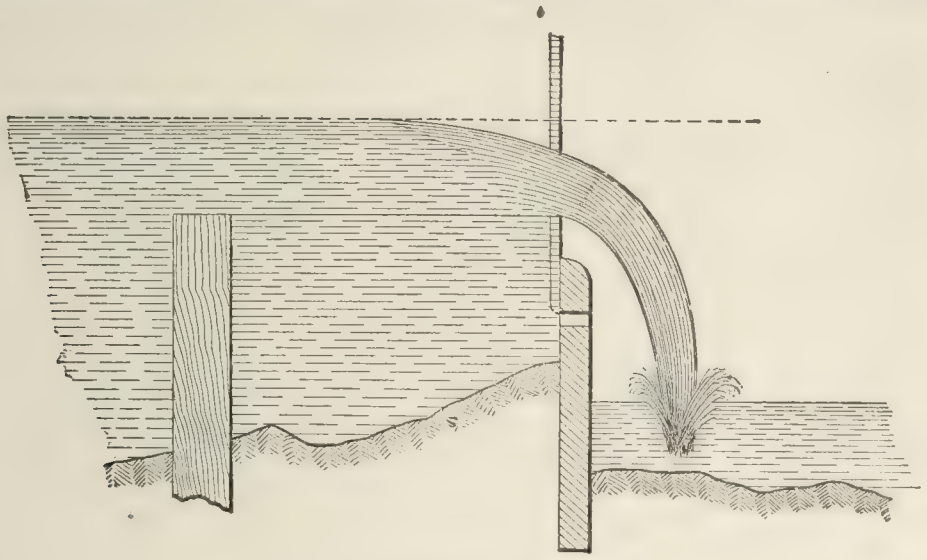


FIG. 10.—Side View of Weir.

furnished by the stream should be determined. Should it be required to ascertain the yield with great exactness, the plan most generally adopted by engineers consists in the use of a carefully leveled weir of thin board or metal in which a rectangular notch has been cut, having a width of one foot. The water flows over this weir in a thin sheet, the difference in height between the apex of the notch and the level of the water flowing through the notch being measured. If the weir is more or less than a foot, the quantity in the table opposite the given depth should be multiplied by the length of the weir in feet, or decimals of a foot. If the weir measure one foot, and the depth of water falling over be two inches, the delivery is read at once, viz., 13.63 cubic feet, or 84.9 gallons, per minute. The following table of reference is given by Notter and Firth:

Depth falling over, inches.	Discharge per minute, cubic feet.	Depth falling over, inches	Discharge per minute, cubic feet.	Depth falling over, inches.	Discharge per minute, cubic feet.
½	1.70	2	13.63	3½	33.22
1	4.82	2½	19.70	4	40.71
1½	8.84	3	26.62		

For the purposes of the military sanitarian, however, sufficient accuracy may be attained by selecting a portion of the stream where the channel is

fairly uniform, and presents no eddies for a distance of fifteen to twenty yards. The sectional area is obtained by measuring the breadth and depth in several places. A chip, cork or other light object is then floated over a certain distance of the portion of channel chosen, the surface velocity in feet per second being thus obtained. The surface velocity, however, is greater than the bottom or mean velocity, and hence four-fifths of the surface velocity—being nearly the proportion of mean to surface velocity—multiplied by the sectional area, will give the yield of the stream per second. It may sometimes be worth while, if labor be available, to remove some of the irregularities in the channel before calculating the yield of a watercourse. For greater nicety the stream may be dammed, and the water passed through an artificial channel, as a wooden trough, of known dimensions.

Where a stream which serves as a source of supply is small, it is frequently desirable to accumulate during the night and hours of non-use the water which would otherwise run to waste, and thus provide a sufficiency for the great demands made upon it at certain periods during

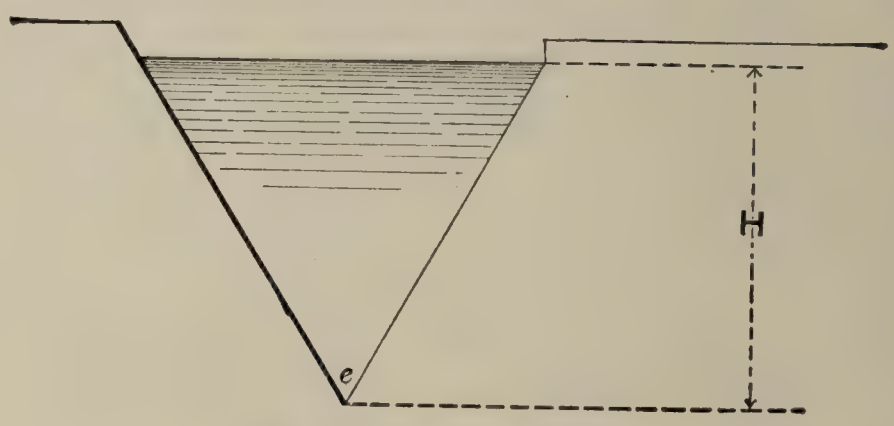


FIG. 11.—Front View of Weir.

the day. The storage of surface water occurs naturally in depressions of the ground surface, and its collection by artificial means consists almost entirely in imitating these natural processes. Special arrangements are necessarily required in each case. In hilly countries a reservoir is usually formed by carrying a dam across a valley receiving the tributary waters of adjacent hills; or on a flatter surface, trenches may be arranged, leading finally to an excavated tank. In form, a reservoir should be deep rather than extended, so as to diminish evaporation and secure coolness. Previous to collecting the water the bottom of a proposed reservoir should be policed, and, as far as possible, be cleared of all vegetable material. Decomposition of recently killed vegetation takes place under water quite rapidly at first, but the process is soon converted into one of exceeding slowness, particularly when the covering water is deep. Alternate flooding and exposure to sun and air is quickly destructive of vegetable matter; and as a result, a reservoir with very gently sloping sides furnishes conditions favorable to a contaminated water supply, particularly if the water be liable at times to considerable reduction in depth. Even though the level of the contents be maintained at high-water mark, sloping sides permit thin layers of water to be overheated by the summer sun; thus encouraging a growth of aquatic plants which subsequently decay to the damage of the water. The reservoir and its vicinity should be kept scrupulously clean, and no possible source of contamination should be per-

mitted to exist. For temporary encampments, the quantity of water to be stored depends usually only on the quantity used, but for permanent garrisons the ease of replenishing must also be taken into consideration. There are also losses incidental to storage which must not be overlooked, these being chiefly due to the processes of percolation and evaporation. The formula for storage given by Notter and Firth is as follows: $D = \frac{1,000}{\sqrt{F}}$ where F represents the mean annual rainfall in inches and D the number of days' supply to be stored.

It should not be forgotten that surface water is extremely liable to pollution, and hence a careful inspection of the surroundings of a proposed source of supply is of the greatest importance, the question of the probable healthfulness of such water being often necessarily decided, in the military service, by such inspection. Surface water is particularly liable to contamination by sewage, manufacturing waste or organic refuse; by manure washed down from cultivated lands of the watershed; by animals pastured on the gathering ground or having direct access to such water supply; by

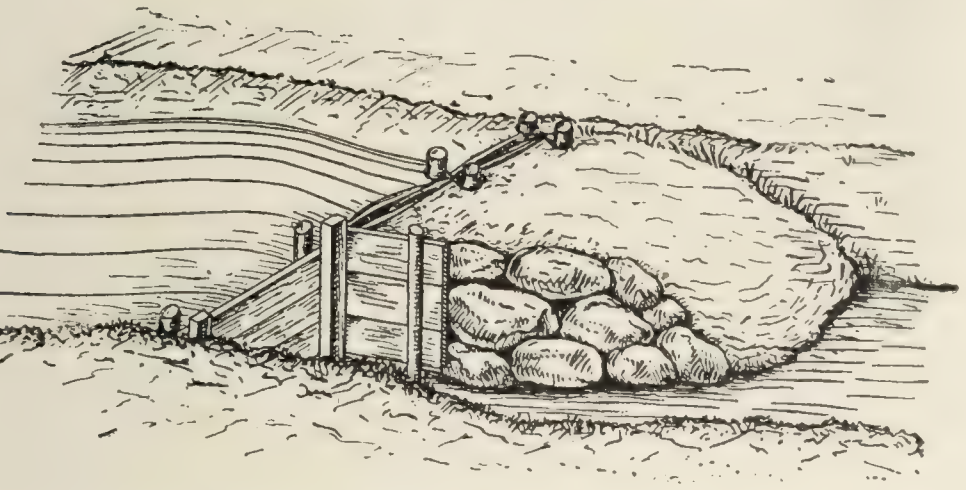


FIG. 12.—Method of Forming Reservoir for Camps.

dead animals in such situations; by refuse from encampments and by persons bathing or washing clothing. Of these, contamination by sewage and organic refuse is the most important in its relation to health, and with the settling up of sparsely settled districts such later contamination of the water supply has forced the abandonment of garrisoned posts, recently that of Fort Custer.

Where surface waters are used as a source of supply by a marching command, great care is necessary to prevent a supply, originally pure, from rapidly becoming contaminated and unfit for use as a result of lax sanitary administration; the danger being less in the case of ground waters. To this end the officer entrusted with the duty of forming an encampment for troops in the field will promptly place a guard over the water supply, taking the sentries from the first troops that arrive on the ground. When the camp is completely formed, the regular guard should take charge of the supply. Under such circumstances every effort should be made against waste, against pollution, and against the turbidity which results from trampling the margin of a surface supply into mud. If the camp is of any permanency and the water is derived from a small stream, the approach should be paved and so located that the water may be dipped from the main current and not from a foul eddy. Where the supply is

taken from such a source, the water used for drinking should be drawn from a part well above the camp; for watering animals a place should be selected below this, and the lowest part devoted to bathing and the washing of clothing and utensils. Where an encampment is located on a large body of water, as a lake, the points at which water may be drawn, animals watered and washing carried on should be widely separated and specially designated. Where a camp is of any permanency, water will be best given to animals, if the supply is limited, by receiving it first in troughs, as by so doing less disturbance of the stream results. As a general rule, the less the water supply the greater the care necessary to maintain its purity.

An essay for the use of volunteers, published in 1861, advised placing latrines over running water when possible. Fortunately this was corrected in the next edition; but the same mistake was made by raw troops during the war with Spain, and the incident is cited to show that the importance of guarding the water supply is sometimes strangely overlooked. Nothing is better established than that no refuse, and especially no fecal matter, should be discharged so as to follow a stream, either directly or indirectly, unless it be one of the great rivers, and then only when it is certain that the water is to be used by no one within a reasonable distance. It is suicidal to pollute small streams which may possibly supply our own forces sooner or later, and it is nothing less than criminal to spread disease in that way among a civil population, or even among an enemy. In hard soil especially, a water supply at a lower level—even if it be at some distance—is liable to be sooner or later polluted in spite of ordinary care and give rise to enteric fever and other water-borne infections.

Ice used in the military service within the United States may be considered as wholly derived from the congelation of surface waters due to natural processes. In freezing, water becomes much purer, losing a large portion of its saline contents, even calcium carbonate and sulphate being largely reduced in quantity. Air at the same time is expelled. Water produced by the melting of ice is thus usually pure but heavy and non-aërated. Snow water contains less ammonia, carbon dioxide and dissolved oxygen than rain water. Clear ice is much purer, as regards both mineral and organic matter, than snow ice; the former containing only six per cent. where the latter contains twelve per cent. of the organic matter in the water from which they were derived. As to bacterial life, Notter and Firth state that snow ice has been found to contain as much as eighty-one per cent. of the amount present in the water, while clear ice contains only two per cent. Prudden found the number of bacteria, per cubic centimeter, in water derived from several samples of melted ice cut from the same cake, to be as follows: Transparent ice, 2,322; bubbly-streak ice, 26,049; snow ice, 55,062.

It is thus obviously much safer to use clear ice for cooling drinking-water, and for placing in contact with food. If distilled water is employed in its manufacture, artificial ice made by the can system is extremely pure. Where ordinary water is used, the outer portion of the cake is proportionately free from impurity, but the centre of the cake, through concentration, is highly impure. Prolonged freezing has no marked effect upon the vitality of the typhoid bacillus, though alternate freezing and

thawing have. It should, therefore, be an unvarying rule that ice should never be cut from bodies of water which are not in every way suited for drinking purposes, and due care should be taken to prevent its contamination during the operation of harvesting and storage. Ice may be fairly well preserved in cool climates, for use in warmer weather, by heaping it up in layers, protected by sawdust, under an ordinary shed; or by storing it in the same manner in properly drained excavations in the ground. For permanent posts, ice-houses should be constructed on the general plan detailed in the section on tropical hygiene.

Ground Water.—Spring water is both pure and impure in different cases; and the mere fact of water being derived from a spring is not, as sometimes imagined, necessarily an evidence of goodness. As a general rule, however, water derived from such a source may be regarded as of excellent quality and well adapted for use by troops. No small number of stations in this country are supplied with water from springs, among them being such important posts as Angel Island, and Forts Huachuca, Snelling, and Robinson. For standing camps, springs have the greater merit of being a source of supply the contamination of which can be readily prevented. Pasteur and Joubert long since found that spring water, on emerging from the soil, usually contained but few micro-organisms, while after comparatively brief contact with the surface it contained vast numbers. Spring water is clear and bright, in consequence of the great degree of filtration which it naturally undergoes in percolating through the strata which it may have traversed between the gathering ground and the point from which it issues again from the earth. For the same reason it is generally cool, unless coming from a depth much above two hundred feet; and by the reason of the gas it contains, is sparkling and brisk to the taste. The temperature of spring water varies, and is generally regulated by the depth.

The yield of a spring is determined most readily by receiving the water into a vessel of known capacity and timing the rate of filling. The spring should have previously been opened up and the receptacle employed should be of large size. The capacity of the vessel used as a standard may be found by filling it by means of a known measure or by determining its several dimensions, capacity in cubic feet being reduced to gallons by multiplying by 6.23. If a tub or cask only be procurable, its capacity may be determined by measuring the diameter midway between the bung and the head, designating this measurement M. The bung diameter is called B, the head diameter H and the length of the barrel L; then $(H^2 + B^2 + 4 M^2) \times L \times 0.0004721$ will give the contents in gallons. Should a spring be steady but small in volume an increased supply may frequently be obtained by digging out the spring head.

A box or barrel, from which the bottom has been removed, should always be sunk in a spring head, to prevent fouling of the water through its disturbance during removal. Where used for any length of time a spring should be enclosed, its level raised and the ground made to slope away from rather than toward it. If this is impracticable, the vicinity should be so ditched that all surface drainage from higher ground is intercepted and conducted to a point below the level of the spring. The latter should be frequently cleansed and all accumulations of leaves or débris removed.

Artesian wells are practically springs of artificial origin. They are generally of great depth and tap a sheet of water held under high pressure between two impermeable strata, both of which crop up elsewhere at a higher level. In the military service, artesian wells will only rarely serve as a source of water supply. During the war with Spain, however, wells of this character furnished the water consumed by troops at several of the large camps in Florida; and they are also in use at the garrisoned posts of Forts Logan, McPherson, St. Francis Barracks and Vancouver Barracks. Water from such a source is usually of excellent quality and contains only a very minute quantity of organic matter. In some cases, however, it is so charged with saline matter as to be undrinkable. The waters of the artesian wells in Florida, above mentioned, were highly charged with sulphur dioxide; this gas, however, being rapidly dissipated on exposure to the air. As a general rule, artesian water is not well aërated and is by no means as palatable as spring water. Laveran states that water furnished by artesian wells is usually quite sterile.

Excavated wells, while properly to be rarely employed as a source of water supply in garrison, may frequently be called upon to supplement a

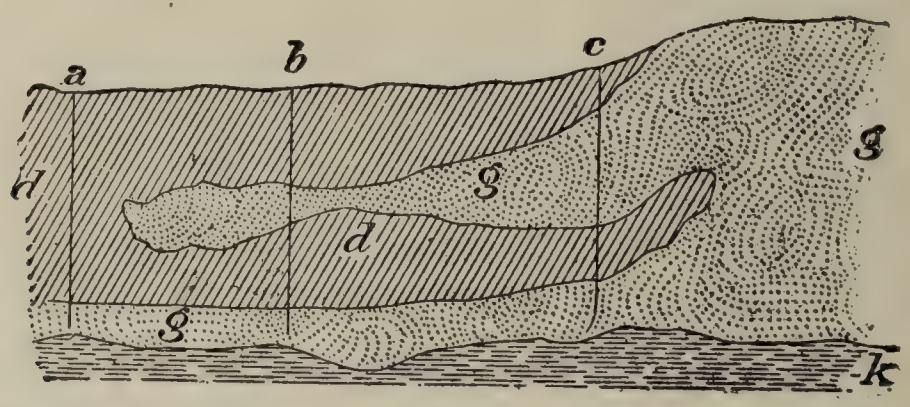


FIG. 13.—Diagram Showing how an Impermeable Stratum, *d*, May Permit Water in Wells, *a*, *b*, and *c*, to be derived from different levels. (After Mason.)

deficient water supply in the field. Such wells are usually classified as deep or shallow, according as the depth is greater or less than fifty feet. Deep wells, rarely found in the military service, are usually good sources of supply; the great efficiency of the filtration which most of these well waters have undergone being attested by their freedom from suspended material, either mineral or organic. Water from such wells is usually pure, and, unless extremely hard, excellent for drinking purposes. Shallow wells, on the contrary, are readily exposed to contamination by surface drainage or soakage, and the water from such wells is always to be regarded with suspicion. The amount of organic matter in shallow wells is usually large, and is too often of animal origin. In locating such wells in the field the ground for a radius of one hundred yards should not be camped upon and a site should be selected entirely free from the danger of overflow by storm water. If possible, the mouth of the well should be sheltered, and a sufficient coping to prevent possible accident and limit contamination is always necessary—the level of the surrounding ground being made to slope from and not toward the mouth to prevent the entrance of surface water. Precaution should be taken for the conduction to a short distance of such water as may be spilled after being drawn, so that it is not immediately returned to the well saturated with the organic

material dissolved during percolation through the necessarily polluted soil around the well site. When used in garrison, wells should be stoned and rendered impervious to surface soakage by an interior coating of cement; but in the field this precaution is obviously impossible. For very shallow, temporary wells, an excellent plan to prevent caving of the walls and facilitate the drawing of water consists in a framework of plank, set in the excavation, the earth previously removed being packed around this frame. For wells not greater than twenty-five feet in depth, in soft soil, the removal of earth during the process of excavation may be accompanied by the forcing down or building of a protecting frame, these frames being necessarily made progressively smaller as the depth of the well is increased. For such wells a light pump provided with a rubber pipe of sufficient length to reach the water level can be used with advantage. A pump is always much superior to the rope and bucket system, through the lessened danger of pollution by the former means.

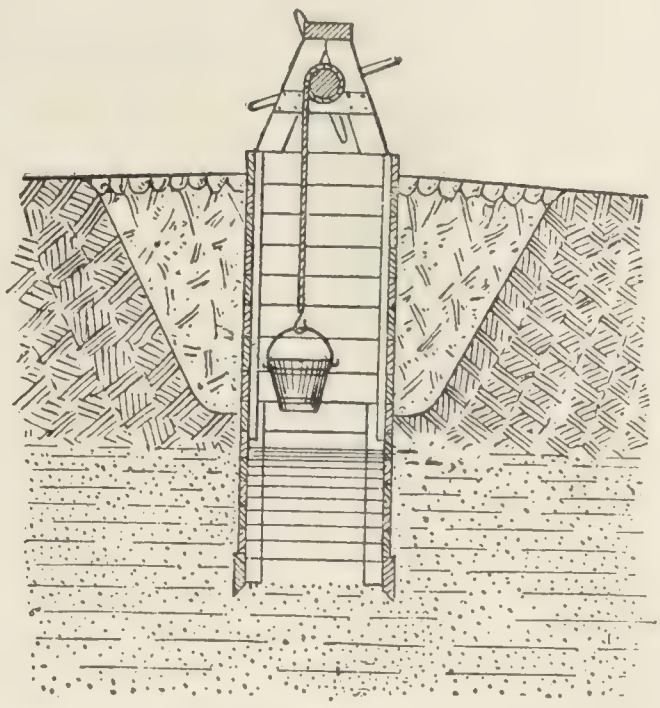


FIG. 14.—Temporary Well for Encampments.

A well drains an extent of ground around it nearly in the shape of an inverted cone. The area must, of course, depend upon the soil; but it has been demonstrated that the radius of the surface area drained is ordinarily at least equal to four times the depth, and that it often exceeds this. The curve of the subterranean water-level rises suddenly near the well and becomes gradually flatter as it extends under the ground surface, the distance to which it reaches depending on the lowering of the level of the water in the well. Thus a shallow well heavily pumped may drain a wider area than a deeper well under moderate pumping—this fact being of great significance in connection with wells in a densely populated encampment, where soil pollution is both extensive and rapid and where the withdrawal of water is constant and great. The distance to which the influence of pumping is felt on the ground water is very variable, ranging from fifteen to one hundred and sixty times the depression of the water in the well. A well which yields a moderate quantity of good water may thus, if the demand on it be increased, draw water from the surrounding parts to meet the demand, and thus tap sources of impurity which a moderate demand left untouched. A sudden rise in the ground water may also lead to communication between a cesspit and a well, by the water tapping the former in its flow. The trend of the sub-soil water at any given point being always in the direction of the nearest natural outlet, when such exists—as a spring, stream, or sheet of water—it is evident that the purer water will be found before it passes such possible point of pollution. For this reason it is possible, in the case of two wells situated only a short distance from each other, that one may yield a pure water

and its neighbor one highly contaminated. This point should not be overlooked in the respective location of wells and latrines or other sources of pollution.

Where pollution of a well from a latrine or similar source of contamination is suspected, a large amount of salt dissolved in a considerable bulk of water may be poured into the vault and the water in the well repeatedly examined quantitatively for chlorides. Many coloring substances have also been employed for this purpose, and among these fluorescin and methylene blue have been found to be the most satisfactory. According to Trillat, fluorescin may be detected in a strength of one part in two billions of water. All colors are removed by peat. Clay and sand let colors pass freely, but humus and garden soil retain all but fluorescin and acid fuchsin.

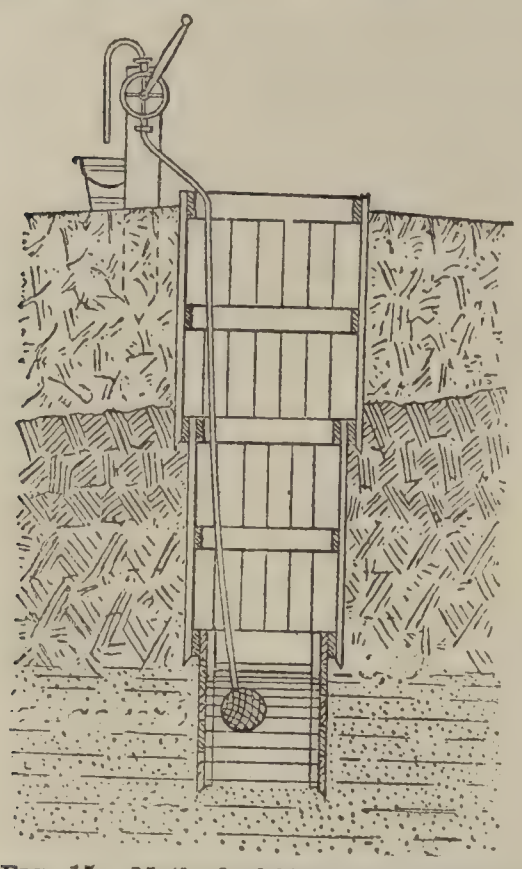


FIG. 15.—Method of Sinking Temporary Well for Camps, Showing Portable Pump and Filter.

The yield of wells can be determined only by lowering the water to a certain level and noting the length of time required for refilling,as well as measuring the quantity removed; the complete removal of the water is unnecessary for a sufficiently accurate estimate in this respect.

Where the water supply, especially for encampments, must be derived from existing wells, a careful inspection of their character, and particularly of their surroundings, should be made. The water of those located in the vicinity of refuse heaps or privy vaults should be carefully avoided. It is said by Bashore that in the state of Pennsylvania the proportion of typhoid fever is fifteen times greater in the country districts than it is in cities; this being explained by the fact that the population in the former case is obliged to depend upon well water, drawn from ground water often infected from privies which at one time or other have contained typhoid excreta. Unless properly protected at the top, wells are liable to con-

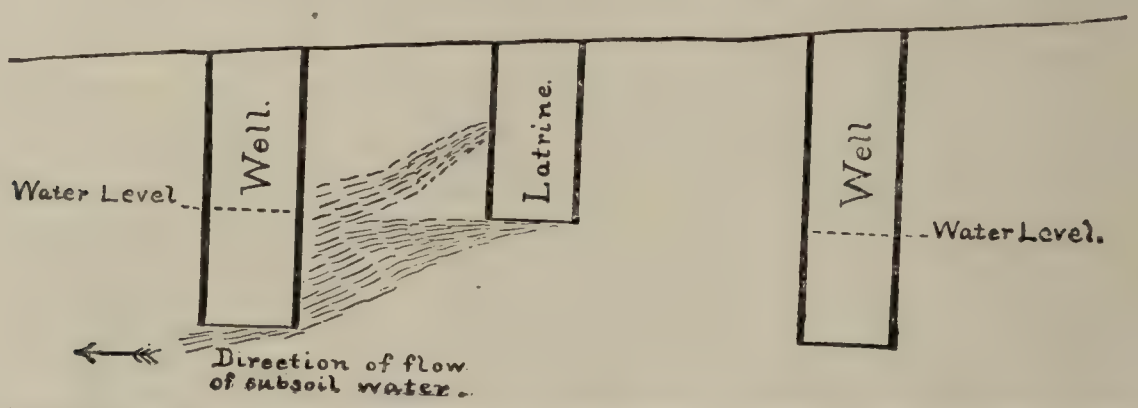


FIG. 16.—Diagram Showing Pollution of Well from Latrine through Trend of Ground Water.

tamination by small animals and refuse which may fall in through the open mouth. In porous soil, surface waters readily percolate into wells with unprotected sides, frequently following the course of the suction pipe if this be carried out through the wall. In wells of long standing, rat-runs,

the burrows of small animals and earthworms and the roots of dead trees frequently increase the danger of such contamination, by allowing direct access of surface water without it being first filtered through the soil.

Excavated wells are still used as important sources of supply at certain Western posts. Among these are Forts Riley, Bayard, Keogh, Yates and San Carlos. Their use should be discontinued.

Driven wells, commonly known as Norton's tube wells, were much used during the Civil War and have been generally adopted in foreign military services. In the British expeditions in Abyssinia and the Soudan they gave excellent results, and they are now successfully employed at Forts Monroe, Assinniboine, Reno, Barrancas and other stations. At most of these stations water is found at no great depth, not more than fifteen or twenty feet. At Barrancas, however, the wells which supply the post are driven much deeper.

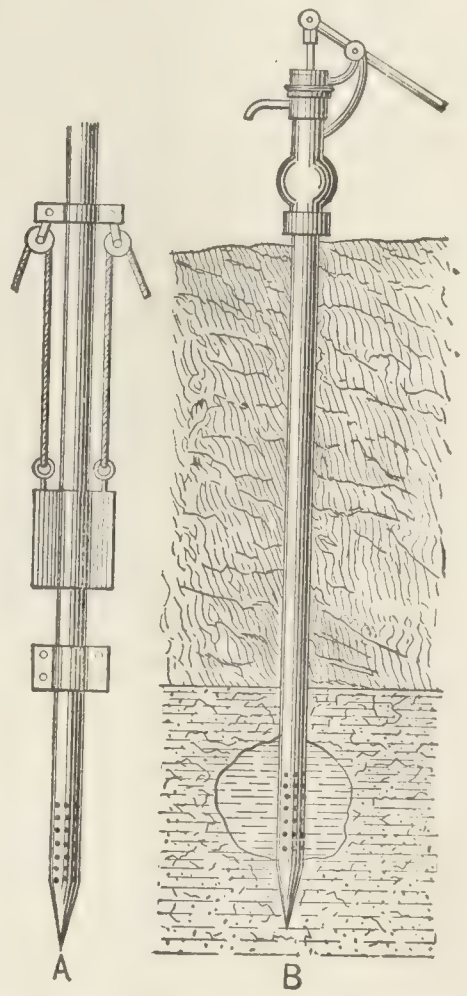


FIG. 17.—A, Apparatus for Driving; B, Driven Well.

These wells are made readily available where a temporary supply is required, and are far superior to dug wells as being much less liable to surface pollution. Fraenkel found, in a central district of the city of Berlin, that water drawn from a driven well sunk to a distance of four meters below the surface was germ-free. Where the driven well is used it is obvious that direct contamination of the ground water from the surface is avoided; and it is important to remember in this connection that bacterial life diminishes as the depth below the surface increases, due to excess of carbon dioxide, deficiency of oxygen and a degree of coolness unfavorable to the development of micro-organisms. Concerning the purity of water afforded by driven wells, the commission investigating this subject for the London *Lancet*, in 1899, reported that while such water "is not wholly free from risk, yet where the tube passes through an impermeable stratum the risk is reduced to a minimum."

To establish a driven well, a section of iron pipe, shod with a perforated steel point, is forced into the ground by a mallet or adjustable weight, additional lengths of pipe being screwed on as required. After being driven down to the water-level a common pump is attached. On pumping a short time the water becomes clear and a cavity is formed around the lower end of the pipe, through removal of the finer particles of soil by suction. Where the water is not more than twenty to twenty-five feet below the surface a supply can be obtained with little trouble, the yield being about seven gallons per minute. If the water lies at a lower level, a special pump becomes necessary. In the British army the Bastein pump is used for this purpose, having an endless chain and worked by two men at a wheel; the yield, from a depth of forty-five feet, being said to be about twenty-two hundred and fifty gallons per hour. If necessary, the pipes can be driven to a depth of as much as one hundred and fifty feet below the sur-

face. Driven wells are used to best advantage in gravel, coarse sand and chalk; their use in clay, marl or fine sand being less satisfactory through the greater liability of the pipe to become blocked. The pipes naturally cannot be driven through rock.

Koch recommends that tubes be placed in all dug wells—the surrounding space to be filled in with clean gravel and sand and the water raised by a pump fixed at the surface.

Search for Water.—Occasionally the sanitary officer will be in a position in which he has to search for water, but for this procedure few precise rules can be laid down. On plains, the depth at which water will be found naturally depends on the permeability of the soil and the depth at which a stratum of hard rock or clay will support the ground water. The plain may be surveyed, and if any part seems below the general level it should be selected for excavation or trial by means of driven wells. The part with the most luxuriant herbage is likely to present water nearest the surface, while morning mists or swarming insects are said sometimes to mark the vicinity of water below. In a rough country the search for water is easier. Hills store up water, which seeks a low level at their base. Wells should be sunk at the foot of hills, not on a spur but at the lowest point; and if there are any indications of a former watercourse, as near to it as possible. The junction of two long valleys will, especially if there is any narrowing, generally give water. The outlet of the longest valleys should be chosen, and if there is any trace of the junction of the two watercourses the well should be sunk at their union. In a long valley with a contraction, water should be sought for on the mountain side of the contraction. In digging at the side of a valley, the side with the highest hill should be chosen. Before commencing to dig, the country should be as carefully looked over as time and opportunity permit and the dip of the strata made out if possible. A little search will sometimes show which is the direction of fall from high grounds or a watershed. If moist ground only is reached, the insertion of a tube, pierced with holes, deep in the moist ground will sometimes cause a good deal of water to be collected. Near the sea, water is generally found; even close to the sea it may be fresh if a large body of fresh water flowing from higher ground holds back the salt water. But usually wells sunk near the sea are brackish and it is necessary to sink several, passing farther and farther inland till the point is reached where the fresh water has the predominance.

Transportation of Water.—Under certain military conditions the carriage of water over considerable distances becomes necessary, creating a problem as important from the military and sanitary standpoints as it is difficult of solution. Where transported in water-carts, barrels or other receptacles the supply is necessarily inadequate for all purposes, and is moreover exposed to the constant danger of pollution. In the British service special water-carts are employed during campaign. The French commonly use metallic barrels for this purpose, carried in wagons or by pack animals. During the autumn manœuvers in France in 1892, when an outbreak of cholera was anticipated, the experiment was tried of providing sterile water in wagons, at certain points, for the use of troops. Sentinels were posted over all other available sources of supply to prevent their use. In Algeria, the French colonial forces use water-skins. To ac-

company the British force which went to Hasheen, during the operations in Egypt, thirteen thousand gallons of water were loaded on seven hundred camels. The water was carried in galvanized iron tanks, made in three sizes. Two twelve and one-half gallon tanks, exclusive of the saddle, weighed three hundred and sixteen pounds. This question of weight is a matter of serious importance in the transportation of water. One gallon weighs about ten pounds, and on this basis estimates may be made.

In our service, twenty years ago, a supply of wholesome water on tap in the kitchens and lavatories of garrisoned posts was a luxury found only in certain permanent garrisons near large cities. At Western stations the water used was frequently hauled in wagons over long distances, and within the past ten years it was reported that the water used at Fort Sisseton, since abandoned, had all to be transported in wagons from points three and nine miles distant respectively. Of late years, however, the water

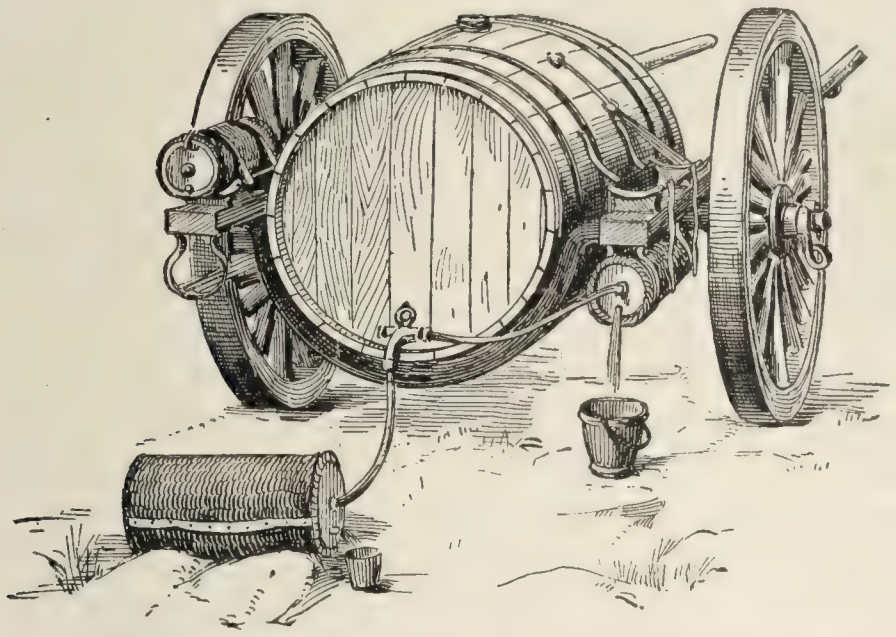


FIG. 18.—Field Water-wagon Used in the British Service, with Maignen Filter Attachment.

wagon has become practically a thing of the past, existing only at the small posts of Forts DuChesne and Eagle Pass.

During the war with Spain, at several of the large volunteer camps in this country, the absence of a properly piped water supply necessitated the transportation of water from distant sources. This was usually accomplished by the aid of wooden barrels, too often covered by dirty gunny-sacks. The results were highly unsatisfactory in all respects. Where receptacles of such character must unavoidably be used, they should be provided with tightly fitting covers and be daily scrubbed and scalded. If this precaution is not taken, the dirty receptacle, especially in warm weather, will promptly contaminate water originally pure. Inspection of the source from which such water is derived, and the manner in which loading and handling are performed, should be frequently made. A wisp of clean grass or hay, or something floating on the surface of the water, will prevent splashing. Where a supply of pure water is sufficient only for drinking and an additional supply of an inferior quality is provided for other purposes, great care and constant oversight on the part of officers are required to ensure that each grade of water is properly utilized by troops. It need scarcely be said that a piped water supply for all garrisoned posts is a fundamental sanitary necessity.

For summer camps of mobilization and instruction, where surface pipes can be employed without danger of freezing, pipe lines for the supply and distribution of water can readily be put down, this procedure implying but a small amount of labor and comparatively slight expense. Beckurts states that five or six inch pipe can be laid at the rate of a mile a day by a gang of twelve men, and that a four-inch pipe can be laid fifty miles in a day by a gang of one thousand unskilled laborers; provided the pipe be first delivered along the line where needed and the country to be traversed presents no unusual difficulties to the engineer. If necessary, as in desert campaigns, pipes may even be laid by advancing troops at the rate of eight or ten miles daily. Such pipes should be laid in successive curves—the plane of the curves being parallel to the surface of the ground—to allow for expansion and contraction due to variation of temperature and to permit of settling without breakage. Where the supply of water by means of gravity is not possible a small pumping engine is necessary. To pump thirty-six thousand gallons of water in twenty-four hours against a pressure of one thousand pounds per square inch would require an improved

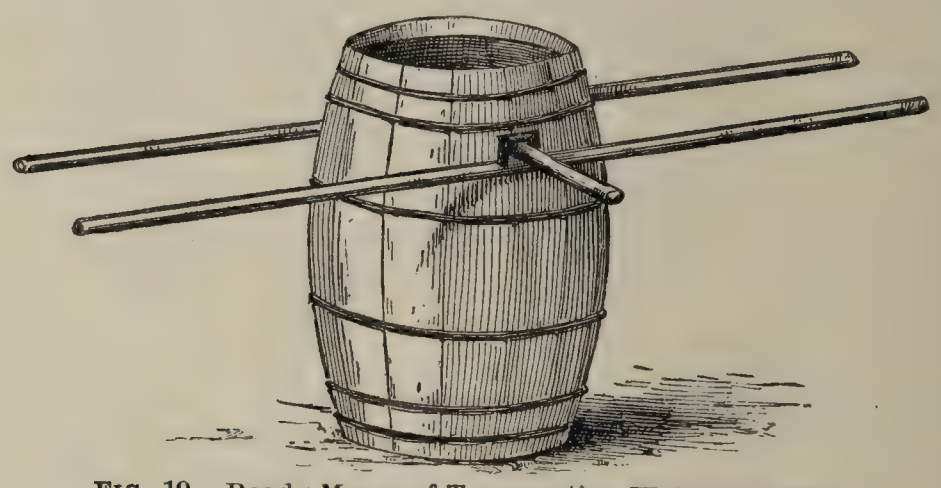


FIG. 19.—Ready Means of Transporting Water in Camps.

pump of about seven thousand five hundred pounds weight with a thirty horse-power engine. The total weight of such a pumping plant need not exceed thirteen thousand five hundred pounds, the fuel consumption being about two hundred pounds of coal per hour.

For semi-fixed camps or encampments of instruction or mobilization, it is evident that the selection and retention of camp sites in close proximity to the water-supply are by no means absolutely necessary. By the use of pipe lines of no very great length, damp and unhealthful locations may readily be avoided and the practical difficulties in the way of a frequent change of camping grounds, over short distances, are largely overcome. There is no reason why the location of all encampments of the above character, at least within the limits of the United States, should not be determined largely by the salubrity of the site itself, and to a considerable degree irrespective of the immediate vicinity of the source of water-supply. This is a practical sanitary question which has received too little attention from military authorities.

For permanent garrisons, all water mains should be made of cast iron. Where placed on soft or made ground they should be laid on a bed of cement or concrete to prevent cracking by settling, and should also be protected from contact with brick or plaster rubbish containing lime, which is liable to corrode the pipe. Where laid under roads they should be

bridged over to avoid damage by heavy traffic. The mains should be kept at least three feet below the surface of the ground, in warm or temperate climates, to secure an equable temperature, and under all circumstances they should be laid well below the frost line. Where long lengths of iron pipe are employed it is usually necessary to provide expansion boxes. In laying large cast-iron mains the joints are made tight by packing them with yarn and then running in molten lead, afterward driving this home with an iron caulking tool; care is required that none of the yarn is allowed to get inside the main, and as little should be used in each joint as possible. Water passing through very long mains may become contaminated through the decay of the yarn used in the joints. For many reasons it is desirable to tar or otherwise protect all mains internally in the prevention of rust; and for this purpose Smith's process is excellent, the pipes being coated internally with a form of black enamel, while hot, immediately after casting. Owing to the large amount of oxygen present in very soft water, rust will frequently form in masses that greatly diminish the discharge from the pipes. Difficulties frequently present themselves in laying long mains, owing to the contour of the ground, and levels in all cases must first be carefully taken. No loss of head will arise through the pipes following the contour line, provided they do not rise above the level of a line drawn from the highest to the lowest point—the so-called hydraulic mean gradient. Should they do so, air will accumulate at this point and loss of head will result. It should not be forgotten that a slight loss of head is caused by every bend, in proportion as it is more or less acute. In deciding the size and thickness of iron mains the following points have to be taken into consideration: (1) The quantity of water required per minute; (2) the height of head; (3) the length of main for friction; (4) the height to which a jet of water is required to be thrown. The enormous loss of pressure by friction, in long lengths of small pipes, is a point too frequently disregarded.

In certain instances the distribution of water is possible through gravity alone, but usually it is required to be raised to an elevated tank or reservoir for subsequent distribution. For small detachments this may be done by wind-mills, but the supply so obtained is both small and precarious. Steam power is usually employed for this purpose in large isolated garrisons, and presents numerous advantages. For small commands, where the water supply is derived from a stream, a water ram is at once the simplest and most economical engine to use, provided the height to which the water is to be raised does not exceed some one hundred and fifty feet. With any height much above this, the amount of water wasted, in proportion to that raised, is excessive. A ram cannot be used with a less fall than twelve inches, and one greater than six feet is not desirable, owing to the strain and constant wear of the apparatus. A ram will not raise water to a greater height than that of twenty-five times the height of the fall given; in practice it is usual to keep well within this limit. The fall necessary to raise a given quantity of water depends upon the volume available in the stream or reservoir, the friction due to the length of the delivery pipe and the height to which the water has to be raised. Rams are ordinarily capable of utilizing from fifty to eighty per cent. of the available power.

Wherever troops are stationed in or near large centres of population the use of the water supply provided for the civil community will almost uniformly be of advantage. Experience, however, has shown that the water question at posts is not invariably settled by connection with the city supply, although satisfactory quality is ordinarily insured. At Vancouver Barracks the needs of the rapidly growing civil population, located on a lower level, produced a serious deficiency of water in the post, which was finally relieved by sinking an artesian well. At Jefferson Barracks, also, the quantity of water used in the city of St. Louis so reduced the pressure in the pipes at the post as to render the supply of water quite inadequate at times. In the east, the larger posts nearly all draw their water supply from the mains of the civil communities to which they are adjacent.

II.

DRINKING-WATER IN ITS RELATION TO DISEASE; AND THE METHODS EMPLOYED FOR THE DETERMINATION OF ITS QUALITY.

While quantity is an accident which gives concern only in occasional cases, the quality of water used by troops is an essential which must receive consideration in each instance. Not only may the organic or inorganic substances held in suspension or solution in an impure water have an unfavorable influence, either mechanical or toxic, upon the bodily functions, but certain pathogenic micro-organisms find in it a vehicle by which an entrance into the organism may be readily effected. Further, water frequently serves as a carrier to various animal parasites which, through their subsequent development, may seriously impair health.

Diarrhœa not uncommonly results from the mechanical irritation due to suspended earthy matter, and may follow the use of water containing large quantities of microscopical plant life. Water containing much hydrogen sulphide has a laxative effect; and the cathartic influence of waters containing much saline matter in solution—as calcium nitrate and the sulphates of calcium and magnesium—is well known. The alkaline carbonates, however, generally favor constipation. Brackish water produces diarrhœa in a large number of persons, particularly those unaccustomed to its use. Lead, on the contrary, when present in solution, is usually provocative of constipation; and, when occurring in quantities larger than the proportion of one-twentieth of a grain per gallon, is ordinarily followed by the well known symptoms which characterize lead-poisoning. Many outbreaks of lead-poisoning have been observed in foreign armies. Copper and zinc, when dissolved in water, may exert a markedly detrimental effect upon the organism. Dyspeptic symptoms may follow the use of water containing calcium, iron, and magnesian salts, and hard waters frequently induce renal or cystic irritation.

Dysentery is produced by impure water containing certain micro-organisms which are now recognized as being specific, and the instances in which outbreaks of this disease have been traced to the use of water contaminated with fæcal discharges are very numerous. One form of dysentery is caused by the amœba coli, the life history of which is not at present

known, but which presumably finds favorable conditions for its existence and development in marshy soil and stagnant water.

Diarrhœa is a common symptom resulting from the use of water containing a high proportion of bacterial life, the introduction of many varieties of micro-organisms into the intestinal tract being followed by diarrhœa of more or less severity. Laveran states that diarrhœa and dysentery have become much more infrequent among the French troops in Saigon since the use of Pasteur-Chamberland filters on that station; and the great decrease in the frequency of both these diseases among our troops during the war with Spain, as compared with figures for the Civil War, was undoubtedly due to the great attention always given to securing a pure and uncontaminated water-supply.

Water from marshes and stagnant pools has long been considered to be a cause of malarial fevers in those who drink it. It is true that the mosquito is undoubtedly capable of transmitting the malarial plasmodium, but it has not been shown that inoculation by this insect is the only means of producing this affection. Much evidence has been accumulated during the past—if the diagnoses be accepted as accurate—to show that drinking water drawn from certain sources is productive of malaria. In this connection a case recorded by Boudin is instructive. This writer states that 800 French soldiers, in good health, were embarked on three ships bound from Algiers to Marseilles; all arriving at the latter port on the same day. On two vessels there were 680 men, presenting not a single case of sickness among them. On the third vessel there embarked 120 men. Of the latter, 13 had died during the short voyage, and of the 107 survivors no less than 98 were affected with malarial fevers. Among the crew of the same ship not a case of malarial fever had occurred. On investigation, it was shown that the water on the first two ships was pure and good, while on the unhealthy ship the water had been taken from a marsh and had an unpleasant taste and odor. This water, however, had not been used by the crew of the ship. Such examples as the above, together with the many indisputable instances in which malarial disease has suddenly and markedly diminished on the substitution of a pure for a bad water-supply, render it difficult to believe that certain drinking-waters may not be without influence in the causation of malaria.

The dissemination of the specific micro-organism producing typhoid fever is ordinarily—though by no means exclusively—accomplished by means of water contaminated with the excretal discharges of those suffering with the disease. Many instances showing the connection between typhoid fever and an impure water-supply were recorded long before the existence of the typhoid bacillus was suspected, and later scientific investigation has definitely proved what previous observation suggested. In practice, however, the actual demonstration of the specific germ in drinking-water, even when abundant proof exists as to its probable presence, is difficult of accomplishment.

As to the viability of the typhoid bacillus under ordinary conditions there is some difference of opinion, probably to be accounted for by the antagonism which exists against this germ on the part of certain saprophytic micro-organisms commonly present in water. Mason states that it is generally admitted that the "disease germs found in water, rarely, if

ever, increase in number, even if the water be polluted, and they finally die." In this connection Mills writes as follows: "The longest time we have been able to keep the germs of typhoid fever alive in Merrimac water is about three weeks; more commonly they disappear in one week. This short period of existence presents the probable reason why the fever may be readily carried down a river from city to city, while a polluted stream may enter one end of a large pond, whose waters are changed only after months, and a water-supply drawn from the opposite end may be continually free from the disease pollution."

Cholera may be safely classed as one of the diseases commonly spread through the agency of specifically contaminated water; abundant proof to this effect having been collected, especially during more recent epidemics. A bacillus which was experimentally shown to produce typical choleraic symptoms was isolated by Koch from the water-tanks of an infected district in Calcutta, as well as from the excreta and intestinal contents of those dead from the disease; and this bacillus is now accepted as being the cause of cholera. During the epidemic in Hamburg, in 1892, germs possessing all the characteristics of the bacillus of Koch were several times found in the water-supply of the infected districts. In a moist condition this bacillus retains its vitality for months, although it is quickly destroyed by desiccation. Growth is arrested at 59° F. The life of the cholera bacillus in water is comparatively short; Wolffhügel stating that the germ may live two or three weeks in unsterilized tap water. Karlinski found the organism dead after two or three days in unsterilized spring water; while Giaxa observed that this bacillus quickly died in water containing many other bacteria. Gruber and Von Kerner showed that the length of viability of the cholera germ, in ordinary river water and that of the Vienna city supply, was about seven days. In addition to the production of cholera from drinking-water containing the cholera poison, it has been supposed that the use of impure water of any kind predisposes to cholera, though such water cannot actually produce the disease. If water acts in this way, it may be by causing a constant tendency to diarrhœa or by impairing the powers of vital resistance.

Water also serves as a vehicle for a large number of parasites; this being particularly the case in warm countries, where the water-supply should be an object of great solicitude. The more common forms of tape-worm find their way into the organism with the food; but the rarer Bothriocephalus latus may pass in with the drinking-water, since both embryo and eggs exist in river water. The ciliated embryo is said to maintain very active movement in water for several days; at the end of which time it may lose its ciliary covering, and, not being able to move further, perishes—or it may gain entrance into some organism and there undergo development. The eggs of Tænia echinococcus, discharged in the fecal matter of the dog, often find their way into sources of water-supply, whence they may be taken into man. The Distoma hepaticum occurs commonly in the livers of animals—notably sheep and cattle—and is sometimes found in the liver in man, especially in the tropics. The eggs of this parasite are known to be developed in water, and hence the introduction of the living embryo by this medium would seem probable. The Ascaris lumbricoides, or round worm, appears sometimes to gain

entrance to the body by means of drinking-water. The ova of this parasite have been detected in water. The Trichocephalus dispar, in warm latitudes the commonest intestinal parasite of man, is known to flourish in warm, moist soil and water, and its introduction by means of the latter agent may be justly inferred. Oxyuris vermicularis, very common in children but comparatively rare in adults, is perhaps at times taken in with water; although the larvæ are said to be destroyed by long immersion in this fluid.

The Ankylostoma duodenalis — a cause of severe and often fatal anæmia, especially in warm countries — is undoubtedly transmitted by means of water. The eggs, expelled with the fæces, are developed either on hot and moist ground or in water. Frequently associated with the Ankylostoma duodenalis is the Rhabdonema intestinale, the eggs of which bear some resemblance to those of the former parasite but differ from them in being hatched in the human host. It is a common cause of tropical diarrhœa, and probably gains entrance to the body in the same manner as does the ankylostoma. The Dracunculus medinensis, or Guinea worm, has been shown to enter the body of the cyclops or water-flea, which, as an intermediate host, may be taken into the human organism with drinking-water. The Bilharzia hæmatobia, very common in Egypt, was observed among Italian soldiers at Massowah, and is not rare in Tunis. While its mode of entrance into the system is unknown it is believed to be through the medium of water, since it is noted that in Egypt the disease is extremely common in small towns in which the water is of poor quality, but is infrequent in the large cities where a filtered supply is provided. Drinking-water also plays an essential part in the causation of filariasis; the Filaria sanguinis hominis, in embryonic form, undoubtedly gaining entrance to the body through the drinking of stagnant or polluted water in which it has been deposited by the mosquito, now regarded as the intermediate host.

Small leeches are frequently present in water, particularly in warm climates, and these may fix on the pharynx or posterior nares when drinking directly from a stream. This accident is particularly common among the French troops in Algeria; it being stated by Notter and Firth that during a march near Oran there were more than four hundred men in hospital at one time from this cause.

QUALITY OF WATER AS INFERRED FROM PHYSICAL EXAMINATION.

It is obvious from what has already been said that a proper estimation of the quality of a proposed water-supply is of the greatest importance in the military service; particularly since troops, from the nature of their duties, are more frequently exposed to the danger of employing water from undesirable or contaminated sources than is the case in civil life. Hence an investigation as to the probable wholesomeness of water, as used by troops —or designated for their use— is the first duty of the sanitary officer. In route camps, and the temporary strategic sites of active campaign, a chemical and bacteriological examination of the water-supply is manifestly impracticable. The supply must be accepted as presented by nature, or if manifestly impure, with such purification as can be hastily effected—and under

such circumstances the senses must ordinarily be the sole reliance in the determination of quality. Recourse to this primitive method of water examination, however, when fortified by the results of experience and by a careful consideration of collateral circumstances, is extremely valuable in the absence of the more delicate methods of analysis; and as far as the military sanitarian is concerned, it may be accepted, in selecting a source for a water-supply, that ordinary common sense on the spot, when used, is perhaps as valuable as scientific knowledge at a distance.

Color.—Large bodies of water, as lakes or rivers, are blue in tint when pure and wholesome. In small quantities, pure water, after sedimentation, appears colorless; but if viewed through a depth of two or three feet, as in a tall cylinder placed on a white background, a bluish tint is acquired. Many excellent waters are grayish, and a few—as an instance, that of the Dismal Swamp, formerly much prized on board ship—are distinctly brown. Greenish waters usually owe their color to vegetable matter, chiefly unicellular algæ, and are ordinarily harmless. Yellow and light brown waters are most to be feared, as their color is usually due to organic matter, too frequently sewage. These tints may, however, be due to iron salts, although in most cases the iron is precipitated from solution in the form of ferric oxide.

Clearness.—Where the water is of good quality it is usually transparent and limpid, but it frequently happens that water of otherwise excellent character contains considerable earthy matter in suspension. Such waters are readily clarified by sedimentation; this process undoubtedly resulting, as already stated, in the mechanical carrying down of a considerable proportion of the bacterial organisms present. Occasionally it happens that water remains hazy or turbid even after standing for some time, the suspended matter in such case being in a state of very fine division.

With reference to the influence of suspended mineral matter upon health there is some diversity of opinion. It is an unquestioned fact that very turbid water is habitually used by large communities with no demonstrable evil effects, but the preponderance of testimony goes to show that immunity is attained by continued use, and that the stranger in this respect is not upon the same plane of safety with the native. Parkes gives a typical instance of the effect of suspended material in water, as follows: "In 1868, the right wing of the Ninety-second Highlanders going up the river Indus, suffered from diarrhœa from the use of the river water, which at that time was very muddy. The left wing of the same regiment used water from the same source, but precipitated the suspended matters with alum and had no diarrhœa. The right wing then adopted the same plan with like success."

The transparency of a water is usually determined by the use of tall graduates; the depth of such a water through which printed matter may be clearly read being compared with distilled water as a standard. Where the amount of cloudiness is small, the water may be placed in a flask and examined in a darkened space to which a single needle ray of light is admitted; the finely suspended matter, which cannot be seen in a diffuse light, is thus rendered visible.

After sedimentation has occurred, the nature of the deposit may be roughly judged of by the eye, as to whether it is mineral or vegetable,

stained with iron, or the like. The larger living forms, such as anguillulæ, water-fleas, leeches, etc., may also be detected—but satisfactory examination can be made only by the aid of the microscope.

Lustre.—Water which holds a considerable amount of oxygen or carbon dioxide in solution is bright and sparkling, and thus the lustre of a water may be considered as an excellent indication of the degree of aëration. Dull waters are usually of inferior quality.

Taste.—The taste of a water is an uncertain indication of its purity. Any badly tasting water should ordinarily be rejected or purified before use; but water containing a high proportion of animal organic matter and charged with bacterial life is often very palatable. Vegetable matter in stagnant water, if dead and decaying, usually imparts a disagreeable taste, but living plants, with few exceptions, exert little influence in this respect. As regards the proportion of mineral matters present, taste is deceptive and varies greatly with the individual. On an average, the mineral salts ordinarily found in water become perceptible to taste when they reach a strength of about one part in fifteen hundred. Iron, however, can be tasted when present in extremely minute proportions. The pleasant taste of good drinking-water is due entirely to the gases held in solution, water which is not well aërated being flat and unpalatable.

Odor.—Wholesome water will usually be odorless. Many surface waters, however, are crowded with the lower forms of animal and vegetable life; these, especially the algæ, giving rise at certain seasons to odors variously described as "musty," "fishy," and the like. However objectionable these odors may be from an æsthetic standpoint, it has not been proven that they are productive of serious disease. When the small plants themselves are swallowed "they act mechanically, perhaps like unripe fruit, when affecting the health at all, in causing diarrhœa; but the filtered water is harmless." To appreciate the odor of a sample of water a partly filled flask should be tightly corked, warmed to slightly above blood heat and well shaken—the air being inhaled at the moment of removing the cork. Sometimes elevation of the temperature of the water to boiling best develops the odor. Very fair results in the field can be obtained with an ordinary drinking-glass partially filled, closed with the palm of the hand and well shaken. On smelling the wet palm, the odor is at once perceptible. Where the odor is fæcal in character, or is distinctly putrefactive, the water should be rejected.

Other Considerations.—The character of the plant life growing in a water affords assistance in making a rapid estimate of the potability and quality of the latter. Water-cress and green algæ grow only in good water; reeds, lilies and mint indicate water of only moderate quality. As a general thing, cat-tail rushes are found in water unfit for drinking purposes. The species of fish present afford a certain indication as to character; trout especially require extremely well-aërated and pure water for their existence, while pike, gar and catfish thrive in muddy, sluggish and often contaminated streams. Horses and mules frequently refuse to drink water which is of poor quality—or, if they drink, do so sparingly and with manifest reluctance.. The dog, on the other hand, readily drinks water which is obviously unwholesome.

Although the physical characters can necessarily give but a general

idea of the wholesomeness of water, they are extremely important when no more exhaustive examination can be made. If a water be colorless, clear, free from suspended matter, of a brilliant lustre, devoid of smell or taste, except such as is recognized to be the characteristic of good potable water, and especially if its source and surroundings appear to be free from organic contamination, it may, in the large majority of cases, be properly pronounced good and wholesome; while, according as it deviates from these characters, the sanitary officer will be proportionately justified in regarding it with suspicion. In permanent camps or garrisons a pure water-supply is so essential to the health of the command that it should be invariably secured even at the expense of other points less hygienically important. Questions of transportation and finance should invariably be subordinate to a matter so vitally affecting the health—that is, the efficiency—of the command.

CHEMICAL ANALYSIS OF WATER.

As already stated, the chemical examination of water is quite impracticable under the conditions of field service. In garrisons of any standing, however, chemical analyses of the water-supply should be made whenever proper laboratory apparatus can be obtained; and these examinations should be repeated at suitable intervals, or whenever a contamination of the supply is presumed to have been possible. Formerly, when the great majority of military posts were established in healthful and sparsely settled regions, the water-supply was almost uniformly of good character; and where doubt as to quality subsequently arose, it was the approved custom to forward samples of such water for expert examination in the laboratory of the surgeon-general's office. With the new conditions of military service under which our troops are now engaged—in distant, isolated and perhaps insalubrious stations in the tropics and in Alaska—the chemical examination of water will necessarily be much more frequently required; and, further, the performance of these analyses will properly devolve upon the sanitary officers with troops, since it is obvious that the shipment of water samples to Washington would be a matter by no means easy of accomplishment, and in the end capable of yielding only imperfect and unsatisfactory results. For these reasons the following outline of water analysis has been inserted for the guidance of the sanitary officer—care having been taken to select the more simple methods of analysis and to include only such as are possessed of practical value for the military service.

Properly speaking, the chemical analysis of water is really not an analysis at all, but is a series of experiments undertaken with a view to assist the judgment in determining the quality of a supply. The methods of conducting these experiments are largely influenced by the individual preference of the analyst, and are far from being uniform and always capable of comparison; thus introducing elements of confusion where several examinations of the same water are made by different individuals. Some of the substances reported—as albuminoid ammonia—do not exist ready formed in the water, and are but the imperfect experimental measures of objectionable organic constituents of which present lack of knowledge prevents a direct estimation. Chemical analysis merely indicates the possibility of danger, by showing the quantity of food material present in a

water and whether it occurs in sufficient amount to support a vigorous growth of bacterial life; it also shows the presence of material which, under certain circumstances, may be looked upon as foreign, and which, under such circumstances, has come, through long experience, to be regarded as associated with dangerous contamination. Chemical analysis, therefore, is merely a guide as to the general character of water, and whether its use in liable to produce disease; reliance being had on bacteriological tests for direct information as regards specific affections and their dissemination by water. One method of investigation is supplementary to the other. Both taken together afford the best basis from which to draw safe conclusions; bearing in mind that while it is possible that a water which is extremely pure from a chemical standpoint may serve as a vehicle for pathogenic micro-organisms, in practice this is rarely the case.

The Water Sample.—As emphasized by Mason, from whose work on water analysis much of the following matter is derived, it is extremely important that the analyst should himself secure the sample of water to be examined; or at least that all information as to its source should be furnished. If this be not done the formulation of a proper opinion as to potability, based on the analytical results alone, may be extremely difficult, if not impossible. A high degree of chlorine may imply either the infiltration of sewage or merely the vicinity of salt water; while much free ammonia, usually pointing to contamination from animal sources, is normally present in water from artesian wells. Hence, however faithfully the various chemical tests may be applied to the question of the fitness or unfitness of a certain water for drinking purposes, there is nothing upon which greater stress should be laid than a thorough knowledge of the source of supply.

For securing samples of water, large glass-stoppered bottles, previously well cleaned and rinsed, are preferable. When these cannot be obtained, a new two-gallon demijohn, fitted with a new soft cork, should be employed. After thorough rinsing, the vessel is filled to overflowing so as to displace the air, and is then completely emptied. Where the water is to be drawn from pipes, a sufficient quantity to empty the local lateral should be allowed to run to waste; if from a stream or lake, the sample should be taken some distance from shore, the mouth plunged well below the surface before the removal of the cork and the vessel submerged about a foot during filling, so as to avoid surface scum. The receptacle should be filled nearly full, be tightly corked and—if to be transported any distance—have a piece of cloth tied firmly over the neck to hold the cork in place. In the latter case, the bottle should be plainly marked with the date, a description of the surroundings and the soil upon which the water rests, together with a summary of the immediate sources of possible contamination. Having secured the sample, analysis should be at once begun, since water is liable to rapid changes during storage; the organic matter, as shown in a report of the Massachusetts Board of Health, ordinarily decaying in about seven days at room temperature. Such organic matter should not be removed by filtration or precipitation, but the water should be presented for examination in the condition in which it is consumed. For this reason, if sediment be present it should be equally diffused by shaking before analysis.

After determination of the physical properties of the water, in the manner already described, the chemical examination is begun, usually by estimation of the total solids. This is done as follows:

Total Solids.—By means of a pipette 100 c.c. of the water is measured into a weighed platinum dish. Evaporation is carried on to dryness on a water-bath, preferably of porcelain and filled with distilled water to prevent the deposit of impurities on the under side of the platinum dish. When dry, the dish and contents are placed in an air-bath and the temperature is maintained in the latter at 105° C. for half an hour; the dish being then cooled in a desiccator over sulphuric acid and weighed. The process of drying and weighing is continued, at intervals of half an hour, until a constant weight is obtained. The final weight, less the known weight of the dish, represents the total solids. This weight multiplied by ten gives the weight of solids per liter, which, expressed in milligrammes, represents parts per million.

This residue may be ignited, moistened with carbonic acid water and again ignited and weighed. Smart conducts the ignition at gentle heat, and says of the value of the procedure: "The blackening during the process is of more interest than mere loss of weight. No matter how few parts are lost, if the lining of the capsule blackens all over, and the carbon is afterward dissipated with difficulty, the water is to be viewed as suspicious." The "loss on ignition," determined by weight of the dish and contents after heating to redness, is usually reported.

While the standard as to the amount of total solids which an unpolluted water should contain is naturally elastic, it has been recommended by Smart that the limits be determined as follows: Safe limit, 300; to be condemned, 1,000.

Hardness.—This is to be divided into permanent and temporary hardness; the former being due to the presence of soluble salts of calcium and magnesium held in solution by the water itself, while temporary hardness is caused by carbonates of calcium and magnesium held in solution by carbonic acid present in the water. Boiling such a water expels the carbon dioxide, whereupon the latter salts separate from solution. Ordinarily the total hardness alone is required to be determined; this being accomplished with a sufficient degree of accuracy by Clark's soap test. In this test the sodium stearate, $NaC_{18}H_{35}O_2$, in soap, coming in contact with the calcium carbonate or sulphate in hard water, is immediately decomposed with formation of insoluble calcium stearate according, in the first instance, to the following equation: $CaCO_3 + 2\ NaC_{18}H_{35}O_2 = Ca(C_{18}H_{35}O_2)_2 + Na_2CO_3$.

In estimating the hardness, advantage is taken of this reaction. A solution of soap is prepared by dissolving 10 gm. of castile soap shavings in one liter of dilute alcohol, made up one-third with distilled water. This solution, if not clear, is filtered. To standardize it, 1 gm. of pure calcium carbonate is dissolved in a little hydrochloric acid, the latter being then neutralized with a slight excess of ammonium hydrate and the whole diluted to one liter with distilled water. Each cubic centimeter of this solution contains an amount of calcium salt equivalent to 1 mgm. of calcium carbonate. Of this solution 10 c.c. is then placed in a florence flask of 250 c.c. capacity and the volume made up to 100 c.c. with distilled water; the prepared

soap solution being run in little by little, shaking after each addition, until a lather is formed which persists for five minutes. Not more than half a cubic centimeter of soap solution should be added at any one time. The amount of soap solution used should be noted; the experiment repeated with 100 c.c. of distilled water and the quantity of soap solution required again noted. The subtraction of the last quantity from the first gives the amount of soap required to neutralize the calcium salt alone; the value of 1 c.c. soap solution, in terms of calcium carbonate, being thus readily determined, as shown in the following example: 8.2 c.c. soap solution are required for 10 c.c. of $CaCO_3$ solution + 90 c.c. water. 0.6 c.c. soap solution are required for 100 c.c. water. Hence 7.6 c.c. soap solution are required for 10 mgm. $CaCO_3$ only; 1 c.c. soap solution thus corresponding to 1.316 mgm. $CaCO_3$. It should be remembered that soap solutions are not permanent and hence require to be standardized frequently.

For the determination of the hardness of a water, 100 c.c. of the sample to be examined should be placed in a 250 c.c. florence flask, the standard soap solution being titrated in according to the method already described. The amount of soap solution required is then read off from the burette, multiplied by the determined value for 1 c.c. of soap solution, and this again multiplied by 10. The result obtained expresses the hardness, in terms of $CaCO_3$, in parts per million of water.

Where the determination of both temporary and permanent hardness is required, the soap test should be made both before and after boiling. Where the hardness due to salts of magnesia is required separately, the water is shaken with a little solid ammonium oxalate, the precipitate of calcium oxalate is removed on a dry filter and the hardness of the filtrate determined. Should a water be so hard as to require for the 100 c.c. a greater amount of soap solution than suffices to saponify 23 mgm. $CaCO_3$, better results are obtained by diluting with an equal bulk of pure water, since too heavy a precipitate appears to interfere with the process of lathering. The average hardness of good waters is given by the British Rivers Pollution Commission as follows: Rain, 3; upland surface, 54; deep well, 250; spring, 185; rivers, 50 to 150.

Chlorine.—This element is ordinarily present in water in the form of common salt, washed from the air or soil or added as one of the constituents of sewage. Under ordinary conditions, away from the sea or salt-bearing strata, a high proportion of chlorine ordinarily indicates sewage contamination. The term "high proportion" applied to chlorine is relative, and should be considered as comparative with regard to local waters of known impurity, since the normal proportion of chlorine varies greatly in different districts.

The determination of chlorine is simple and practically requires but two solutions. Of these, one is usually made by dissolving 5 gm. of potassium monochromate in 100 c.c. of distilled water. The second solution is one of silver nitrate, made by adding 4.7887 gm. of $AgNO_3$ to a liter of distilled water. The potassium monochromate solution is used purely as an indicator; its value in this respect depending on the fact that if to a solution of a chloride, which has been colored yellow by a little chromate solution, a solution of silver nitrate be added, white silver chloride will

be produced until the last trace of chlorine be disposed of, when red silver chromate begins to appear.

The process consists in measuring 25 c.c. of the water sample into a porcelain capsule or glass beaker, the latter—if used—being placed on a piece of white paper to secure a suitable background. The amount of water to be used varies with the proportion of chlorine present. If the first test shows the proportion of chlorine to be high, 25 c.c. will be sufficient; but if the chlorine be low, it may be advisable to evaporate 100 c.c. or more down to about 25 c.c. Two or three drops of the chromate solution are then added, rendering the water distinctly yellow; and then, from a burette, the silver nitrate solution is run in, drop by drop, stirring after each addition. The red silver chromate which is at first formed will disappear as long as any chlorine is available. The titration is stopped as soon as the red tint is permanent. As 1 c.c. of the standard silver solution equals 1 mgm. of chlorine, the number of cubic centimeters required by the sample indicates the number of milligrammes of chlorine in the sample of water measured off. These figures are multiplied by the proper factor to reduce to suitable terms of comparison in parts per million.

As already stated, the normal chlorine varies with locality; and hence a knowledge of the source and surroundings from which the sample of water is taken is of the greatest importance in determining the significance of the proportion of chlorine. Definite standards in this respect cannot therefore be given. It should be noted, however, that pure rain water ordinarily contains from 1.1 to 1.6 parts. Frankland fixes the permissible limit of chlorine, under ordinary circumstances, at 50 parts; but this figure, by most observers, is considered to be much too high.

Organic Material.—There is no direct method by which the amount of organic matter present in a water can be determined; and it is therefore necessary to utilize in its estimation the known tendency of organic matter to decompose into simpler bodies, as nitrites, nitrates and ammonia. Although no better evidence as to the presence of organic matter can be imagined than that based upon the nitrogen resulting from its decomposition, still a practical objection exists in the fact that all harmful organic matter is not necessarily nitrogenous. It is further obvious that no chemical process can determine whether existing organic matter is living or dead; or whether, if living, it is injurious or not. From the microscopical size of bacterial life it is seen at once that considerable numbers of microorganisms cannot by themselves materially increase the organic ammonia; but as they are nearly always associated with an organic nutritive medium, the presence in excess of organic material at once justifies suspicion as to the purity of the water under examination. Viewed from this standpoint, an estimation of the proportion and form in which nitrogen occurs in drinking-water becomes of the greatest importance.

Nitrites.—For the determination of nitrogen as nitrites, probably existing as a result of oxidation of organic nitrogen, the second method proposed by Griess is most satisfactory. This depends upon the red coloration which results whenever sulphanilic acid and naphthylamine hydrochloride are added to an acidified solution of nitrite. The test is extremely delicate and is said to be capable of distinguishing one part of nitrogen as nitrous acid in one thousand million parts of water. The sul-

phanilic acid is used in aqueous solution, 1 gm. being dissolved in 100 c.c. of hot water. In making up the solution of naphthylamine hydrochloride, 0.5 gm. of the salt, is boiled for ten minutes in 100 c.c. of water, the volume of the latter being kept constant. The solution is preserved in a glass-stoppered bottle, a little pulverized carbon being added to decolorize the solution.

A standard solution of sodium nitrite is also required. This is often prepared from the silver salt, which may be made as follows: To a cold solution of commercial sodium or potassium nitrite, a solution of silver nitrate is added as long as a precipitate appears. The liquid is decanted and the precipitate washed twice with cold water, and then dissolved in boiling water. This hot solution is concentrated and the silver nitrite crystallized out. It is then dried in the dark at ordinary temperatures, and stored. When required for use, 0.22 gm. of the dry silver nitrite is weighed out and then dissolved in hot water. The salt is decomposed with a slight excess of sodium chloride, the solution is cooled and diluted to one liter. After the silver chloride has precipitated out, 5 c.c. of the clear solution are removed and diluted to one liter. This second dilution, which is the standard solution to be used, contains an amount of nitrite, per cubic centimeter, equivalent to 0.001 mgm. of nitrogen.

Smart prefers to make up the standard solution of sodium nitrite by preparing a weak solution of commercial sodium nitrite, of unknown strength, and then by the addition of a standard solution of potassium permanganate, converting the nitrite into the nitrate. The amount of oxygen required for the process is carefully observed and from this the quantity of the nitrite in the solution is calculated.

For the determination of the nitrites, 100 c.c. of the water to be examined is placed in a Nessler jar and acidified with a single drop of concentrated hydrochloric acid. Then 1 c.c. of the sulphanilic acid solution is added; followed by 1 c.c. of the solution of hydrochloride of naphthylamine. The solution is then mixed with a glass rod, covered with a watch glass and set aside for thirty minutes. At the same time other Nessler jars are prepared, containing known amounts of the standard solution of sodium nitrite and diluted up to the 100 c.c. mark with pure distilled water, adding the reagents as above. At the end of thirty minutes the shade of the pink color formed is examined, and, by comparing the unknown with the known an accurate determination of the amount of nitrogen present as nitrites may be made.

Nitrites should be regarded with suspicion if found in ground or surface waters. Leeds' standard for American rivers places the permissible impurity at 0.003. The presence of nitrites in spring and deep well waters is said by Frankland to be "absolutely without significance, for although in these cases they are generated by the deoxidation of nitrates, this deoxidation is brought about either by the action of reducing mineral substances, as ferrous oxide, or by that of organic matter which has either been embedded for ages or, if dissolved in water, has been subjected to exhaustive filtration."

Nitrates.—The quantity of nitrates in water assumes importance from a sanitary standpoint since these salts presumably represent a higher stage in the oxidation of nitrogenous organic matter. Mason states that nitrates

are more liable to indicate putrefaction of animal than vegetable tissue; not only because of the greater quantity of nitrogen present in the former but also on account of its more ready decomposition. Nitrogen in the soil is increased by the fixation of atmospheric nitrogen by the roots of certain plants—such as peas—the process being aided by bacterial action. Such nitrogen eventually enters the ground-water; and hence a knowledge of the local normal for nitrates is of advantage in estimating the purity of well waters. Surface and ground waters of good quality are low in nitrates, for the reason that such material is eagerly appropriated by growing vegetation.

The following method for the quantitative determination of nitrates is advised by Mason; the method depending upon the yellow color, due to ammonium picrate, which results from the addition of ammonium hydrate to tri-nitro-phenol; the latter depending for its production, in water analysis, on the addition of phenol-sulphonic acid to water containing nitrates. The intensity of the color due to ammonium picrate in a sample of water is compared with sample colors of known strength, and the quantity of nitrates thus determined. The presence of chlorides interferes with the process, resulting in readings below the truth; and hence the quantity of chlorine in the sample of water under investigation should be previously determined, and an appropriate volume of standardized sodium chloride solution added to each evaporation of standard potassium nitrate solution, so that the water itself and the nitrate solutions with which it is compared shall all contain the same quantity of chlorine.

The phenol-sulphonic acid solution is composed as follows: Pure and concentrated sulphuric acid, 148 c.c.; distilled water, 12 c.c.; pure phenol, 24 gm.

The standard potassium nitrate solution is made by dissolving 0.7221 gm. pure KNO_3 in 1 liter of distilled water; 100 c.c. of this solution being diluted to 1 liter with distilled water. This weaker solution, which is the standard employed, contains 0.01 mgm. of nitrogen as nitrate in each cubic centimeter.

A standard sodium chloride solution is made by dissolving 1.6497 gm. pure NaCl (preferably made from metallic sodium) in 1 liter of distilled water. Each cubic centimeter of this solution will contain 1 mgm. of chlorine.

For the determination of nitrates, 100 c.c. of the water is evaporated to dryness on a water bath; 0.1 c.c. of sodium carbonate solution—made by dissolving 5 gm. of pure Na_2CO_3 in 30 c.c. of distilled water—being previously added to prevent loss from volatilization of nitric acid. After evaporation, the residue is thoroughly moistened with 2 c.c. of the sulphonic acid; and then an excess of ammonium hydrate—about 15 c.c.—is added. The solution is then made up with distilled water to 100 c.c. in a Nessler jar; and the depth of color compared with those produced by operating upon different amounts of the standard nitrate solution, which have been evaporated and treated under precisely similar conditions. This latter requirement is of the greatest importance in insuring reliable results.

As to the allowable amount of nitrates which may be present in potable water, opinions vary. Mallet determined the average in waters known to be pure at 0.42; while in waters believed to be objectionable he found the average to be as high as 7.239.

Ammonia.—The free ammonia occurring in water represents the ammonia combined with carbonic, nitric or other acids, and also what may be derived from urea or other easily decomposable nitrogenous substances, if they are present. Free ammonia in artesian wells is often excessive under conditions that render animal contamination an impossibility; and even rain water, collected after periods of long drought, will often exhibit quantities calculated to mislead the observer. Wells sunk in ferruginous regions often present a high degree of free ammonia—since the oxide of iron, in the absence of oxygen, affords favorable conditions for the development of ammonia. The amount of free ammonia in ground waters of good quality is, however, usually low; and in surface waters the influence of growing vegetation in reducing the quantity of free ammonia is very great. The tendency is for free ammonia to disappear upon keeping. From observations made upon the appearance and disappearance of nitrites there seems to be little doubt but that this diminution in free ammonia is to be accounted for by a process of nitrification; nitrites being formed at the expense of the ammonia.

For determination of the free and albuminoid ammonia it is necessary to have the following solutions:

(1) Nessler's solution. This is made by dissolving 16 gm. of mercuric chloride ($HgCl_2$) in about half a liter of pure ammonia-free water. There are then dissolved 35 gm. of potassium iodide in about 200 c.c. of pure ammonia-free water. The first solution is then poured into the second until a faint show of excess is indicated. To this, 160 gm. of solid potassium hydrate (KOH) is added and the whole diluted to one liter. Finally more mercuric chloride solution is added until a red precipitate of mercuric iodide begins to be permanent. This excess of mercuric iodide should not be filtered from the solution—which should have a pale straw color—but should be allowed to remain on the bottom of the vessel.

Nessler's solution gives a distinct brownish-yellow color with the most minute traces of ammonia or ammonium salts. If the quantity of ammonia be considerable, a brown precipitate will appear.

(2) An alkaline solution of potassium permanganate, made by dissolving 200 gm. of solid potassium hydrate (KOH) and 8 gm. of crystallized potassium permanganate ($K_2Mn_2O_8$) in 1,250 c.c. of ammonia-free water. This quantity is then boiled down to 1 liter.

(3) A sodium carbonate solution, in which 50 gm. of the pure salt are dissolved in 300 c.c. of ammonia-free water.

(4) A standard ammonia solution. This is made by dissolving 1.5706 gm. of pure dry ammonium chloride in 500 c.c. of ammonia-free water; and again diluting 5 c.c. of this solution to 500 c.c. with ammonia-free water. The second solution is the standard employed and represents a strength of 0.01 mgm. of NH_3 per cubic centimeter.

For the determination of free ammonia the following procedure is employed: A one-quart glass tubulated retort is attached to a Liebig's condenser by means of rubber tubing; the neck of the retort being made to project well into the condensing tube. In the retort are placed 200 c.c. of ammonia-free water, and 10 c.c. of the sodium carbonate solution added. Two 50 c.c. jarfuls of water are distilled off, Nesslerizing the second to insure that no ammonia remains in the retort as a result of imperfect cleans-

ing of the apparatus. To the contents of the retort are now added 500 c.c. of the water to be examined. The resulting distillate is received in 50 c.c. Nessler jars; the rate of distillation being so managed as to allow about fifteen minutes for the filling of each 50 c.c. jar. Of the Nessler solution 2 c.c. are now added to each jarful, and the distillation and testing of each separate portion continued until no reaction for ammonia is given after five minutes. Usually four portions of 50 c.c. each are sufficient to carry off all free ammonia. From a small burette definite amounts of the standard ammonia solution, as given above, are measured into several clean Nessler jars. Each is diluted to 50 c.c. with ammonia-free water, and 2 c.c. of the Nessler solution added. After standing five minutes the depth of tints produced are compared with the distillates already treated with the Nessler solution. With a little practice it is easy to produce colors corresponding to those existing in the distillates by properly varying the quantities of standard ammonia solution used; and thereby a most accurate knowledge of the quantity of ammonia existing in the water, either free or as an ammonium salt, is obtained. The final result is obtained by adding together the several quantities of ammonia found to exist in the different distillates yielding a reaction with the Nessler solution—it being remembered that 1 c.c. of the standard ammonia solution corresponds to 0.01 mgm. of NH_3—and the total multiplied by 2 gives the quantity for an entire liter, or parts per million.

Albuminoid ammonia is determined as follows: The residue remaining after the distillation for free ammonia is thrown out and the retort thoroughly rinsed; after which 200 c.c. of ammonia-free water and 50 c.c. of the alkaline permanganate solution are placed in the condenser. Distillation is then continued until three 50 c.c. jarfuls have passed over, the third one being Nesslerized in order to insure freedom from ammonia. Half a liter of the water under examination is then added and the distillation continued, the successive 50 c.c. portions of the distillate being Nesslerized as in the determination of free ammonia. The distillation is continued as long as is compatible with the safety of the retort, unless the ammonia sooner ceases to be evolved. From the total ammonia thus determined, the amount of free ammonia should be subtracted—the difference being the albuminoid ammonia. The calculation is entirely similar to that of free ammonia, as already detailed.

According to Smart, the rate at which the ammonia is evolved is of an importance at least as great as the total amount of the same, he stating that: "Gradual evolution of albuminoid ammonia indicates the presence of organic matter, whether of vegetable or animal origin, in a fresh, or comparatively fresh condition; while rapid evolution indicates that the organic matter is in a putrescent or decomposing condition."

Notter and Firth place the average amount of free ammonia in pure water at 0.01 per million; in usable waters it should not exceed 0.05. In drinking-waters of good quality the albuminoid ammonia should not exceed 0.10 to 0.15 per million.

For water analyses, the preparation of ammonia-free distilled water is a matter of vital importance. This water should be prepared with great care, in a room free from the usual laboratory fumes—and, in fact, the entire chemical examination of water should be carried out elsewhere than

in a general laboratory. The preparation of ammonia-free water consists in distilling good spring water in a large two gallon retort, collecting successive portions of the distillate in 50 c.c. Nessler jars and adding 2 c.c. of the Nessler solution to each. The distillation and testing should be carried on until no reaction with the Nessler solution is obtainable after standing for five minutes. The remaining water may then be distilled off and collected for use; care being taken not to push the distillation too far on account of danger to the retort and the possible production of ammonia from decomposition of the organic material remaining in the bottom.

Oxygen-Consuming Capacity.—Although by itself a determination of oxygen-consuming power is of little value as a measure of the organic impurity of a water sample, this determination of its affinity for oxygen, when taken in conjunction with other analytical facts, is often of material aid in forming an opinion as to the quality of any particular water. Much of the organic matter present in water is capable of oxidation; but since the ease of oxidation bears no constant ratio to the nature of the organic material, its estimation affords no very reliable index to the real pollution present. In all the efforts to judge the oxidizable organic matter, advantage is taken of the fact that, in the presence of most organic substances, permanganate of potassium freely parts with its oxygen until all the permanganate has been reduced to hydrated manganese dioxide. It must be borne in mind, however, that besides organic matter, iron salts, nitrites and hydrogen sulphide will reduce permanganate of potassium. Hence, where these latter are present, due allowance must be made. Peaty waters also consume large quantities of oxygen, and thus the results should always be considered in connection with other analytical data and the source of the water.

The solutions required, according to the method recommended by Smart, are as follows:

(1) A standard solution of potassium permanganate, made by dissolving 0.3952 gm. of the salt in 1 liter of distilled water. Each cubic centimeter of this solution should contain 0.1 mgm. of oxygen available for oxidation.

(2) A standard solution of oxalic acid, made by dissolving 0.7875 gm. of the crystallized acid in 1 liter of distilled water. This solution, if titrated against the permanganate solution, while hot and in the presence of sulphuric acid, should correspond to it, cubic centimeter for cubic centimeter. Ten cubic centimeters of the oxalic acid solution, diluted with 200 c.c. of pure water and 10 c.c. of the dilute sulphuric acid, should be titrated, boiling, with the standard potassium permanganate solution, and the amount of the latter required should be recorded.

(3) A solution of dilute sulphuric acid, made by adding one part of the strong acid to three parts of distilled water.

The determination is made as follows: Place 200 c.c. of the water under examination in a porcelain casserole, add 10 c.c. of the dilute sulphuric acid and run in the standard permanganate solution from a burette until the water has a very marked red color. The solution is then boiled for ten minutes, more permanganate being added from the burette from time to time, if necessary, in order to maintain the intensity of the red color observed at the outset. This color should be kept as nearly constant as possible by

gradual addition. The heat is then removed from the casserole; 10 c.c. or more of the oxalic acid solution is added—sufficient to destroy the color—and the permanganate solution is again added from the burette until a faint pink tinge again appears. From the total permanganate used an amount must be deducted corresponding to the quantity of the oxalic acid solution employed, and from the remainder may be calculated the milligrammes of available oxygen consumed by the organic matter present in the water. It should be remembered that urea is not oxidized by this treatment. By this test alone, therefore, a water which contains urea may give apparently excellent results.

The average oxygen-consuming capacity for waters of varying purity may be considered to be as follows: Pure, 0.6; doubtful, 3.0; impure, 6.0.

Dissolved Oxygen.—For the determination of oxygen held in solution the best method is probably as follows: A pipette of about 100 c.c. capacity is provided with an upper and lower stopcock, and the capacity of the same between the stopcocks is determined. Above the upper stopcock the tube is expanded into a short, cylindrical funnel. The pipette is completely filled with the water to be examined, by immersion with both cocks open. The cocks having been closed, the pipette is wiped off and fixed in a suitable clamp, with its lower point dipping into a little diluted sulphuric acid. Two cubic centimeters of dilute potassium hydrate are then placed in the funnel and, by careful opening of the cocks, introduced within the pipette without the admission of air. After washing the funnel, 4 c.c. of a solution of ammonium ferrous sulphate are placed therein, and, by similar means, also admitted within the pipette. In the presence of the alkaline solution, the oxygen dissolved in the water will immediately oxidize the ferrous salt to the ferric state, and a mixture of the two hydrates will shortly settle to the bottom after gentle agitation. After again washing the funnel, 2 c.c. of sulphuric acid—equal parts of acid and water—are placed therein, and the upper stopcock alone is opened. The higher gravity of the acid will cause it slowly to enter the pipette, where it will acidify the contents and dissolve the hydrates of iron. The contents and washings of the pipette, together with the acid from the beaker into which the lower extremity of the pipette has dipped, are now turned into a flask and titrated with a standard solution of potassium permanganate; this solution being prepared as described in the method given for the determination of required oxygen. A control flask is now titrated, containing a mixture of 100 c.c. of the water, 2 c.c. of the sulphuric acid, 2 c.c. of the potassium hydrate solution and 4 c.c. of the ammonium ferrous sulphate solution. The difference between these two titrations (acid reaction having prevented oxidation in the second instance) will give the amount of ferrous salt oxidized by the oxygen dissolved in the water. The volume of the water operated upon will be the capacity of the pipette less the quantities of the alkaline and iron solutions employed.

A valuable use of the above method is made beyond the mere estimation of dissolved oxygen. Waters heavily charged with microbes are known quickly to lose their oxygen, while the greater number of algæ, on the contrary, contribute oxygen by evolving it under the influence of light. It is obvious that water stored in a closed vessel will neither gain nor lose oxygen in any length of time except through internal influences—and

hence the difference in oxygen, after proper storage for a suitable period, will approximately represent the quantity of bacteria present. This estimation is made as follows: After an immediate determination of the dissolved oxygen present, a second sample of the water is then introduced into a glass-stoppered bottle, which it completely fills. This is placed in the dark, at a constant temperature of 33° C., for forty-eight hours; such conditions being favorable for bacterial activity, while algæ growth is stopped. At the end of the time stated the dissolved oxygen is again estimated, and the amount found to have been lost will be in a measure proportional to the bacterial contents of the water.

The loss of oxygen, divided by the amount of it originally present, is termed the coefficient of alterability.

Lead and Copper.—It may perchance be necessary for the sanitary officer to examine water for the presence of lead or copper; and the ease with which their dark sulphides may be formed provides a ready method. For this purpose a standard solution of lead nitrate is prepared by dissolving 1.599 gm. of the salt in 1 liter of distilled water. Each cubic centimeter will contain 1 mgm. of metallic lead. The operation consists in placing the suspected water in a 100 c.c. Nessler jar; adding two drops of concentrated hydrochloric acid, followed by 1 c.c. of colorless ammonium sulphide. The tint is matched by operating with measured amounts of the standard lead solution diluted to 100 c.c. This test does not distinguish between copper and lead, but, since both are objectionable, distinction between the two is of no practical sanitary importance.

In conclusion it may here be emphasized that, having pronounced on it in the first instance, the duty of the sanitary officer in relation to the water-supply has only commenced. Constant watchfulness is required to guard against contamination either in source or distribution, and frequent examinations are necessary to detect deterioration before it is forced upon notice by the occurrence of preventable disease. The sanitary bearing of any variation in its constituents must be determined, but above all the organic contamination must be noted at intervals and its increase carefully investigated and traced to its source. Every health officer will acknowledge the necessity of thus guarding the water-supply in camps, where soil pollution is the inevitable consequence of continued occupation and where all formidable outbreaks of water-borne disease are connected with organic impurities. Yet this care is seldom bestowed, chiefly from an impression that the organic matter lies beyond the scope of our present means of research. It is true that its quality and action on the human system cannot be predicated from the results of chemical examination; but, when certain limits of organic impregnation can be defined, within which experience shows the water-supply to be, in general, innocent and beyond which there is liability to disease, a method which can accurately state the position of a given water with regard to those limits should not be disregarded.

THE MICROSCOPICAL EXAMINATION OF WATER.

This, in its broadest sense, includes the bacteriology of water as well as the examination of suspended or sedimentary matter. Ordinarily, however, the former is treated separately and the microscopic examination is

understood to include mineral, dead animal or vegetable matter, or living animal or vegetable organisms—the latter not requiring artificial cultivation for their recognition or determination. This subdivision is convenient for the sanitarian as well as the biologist, since the two classes of living organisms affect water in different ways. With certain reservations it may be said that while bacteria render a water unsafe, the microscopical organisms render it unsavory.

The microscopical examination of water may be considered as of value when regarded from three standpoints: (1) As indicating sewage or other dangerous contamination; (2) as supplementing the chemical analysis; (3) as explaining the cause of turbidity, odors, etc., in water. With regard to the first point it is obvious that direct microscopic examination is incapable of revealing pathogenic bacteria, which ordinarily exist in comparatively small numbers in a great mass of water; and which, moreover, are far outnumbered by ordinary water bacteria. The ova or larvæ of some of the endoparasites of man have, however, been observed not infrequently in drinking-water. Sewage pollution cannot be definitely shown by the microscope unless the pollution is excessive—when bits of textile fabric, starch grains, yeast cells, fibres of wood and paper, epithelial cells, hair and similar articles may be observed. The identification of these matters is of moment as indicating the character of the contamination. Anything which can be unequivocally traced to the habitations of man must always cause the water to be regarded with suspicion; since, if one substance from a house can gain entrance, others may also.

The chemical analysis of a water determines the amount of organic matter present in a water, but does not distinguish as to its special source. Microscopical examination here becomes valuable by showing not only whether the organic matter in suspension is vegetable or animal, but also whether it is made up of living organisms or of decomposing fragments. Microscopic examination has a special importance where the amount of albuminoid ammonia is high, since this may be readily explained by a free growth of some organism. On the other hand, a sudden decrease in the nitrates or free ammonia might be accounted for by the appearance of some microscopic growth that had appropriated the nitrogen as a part of its food.

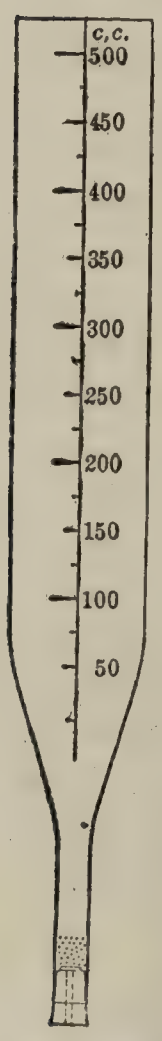
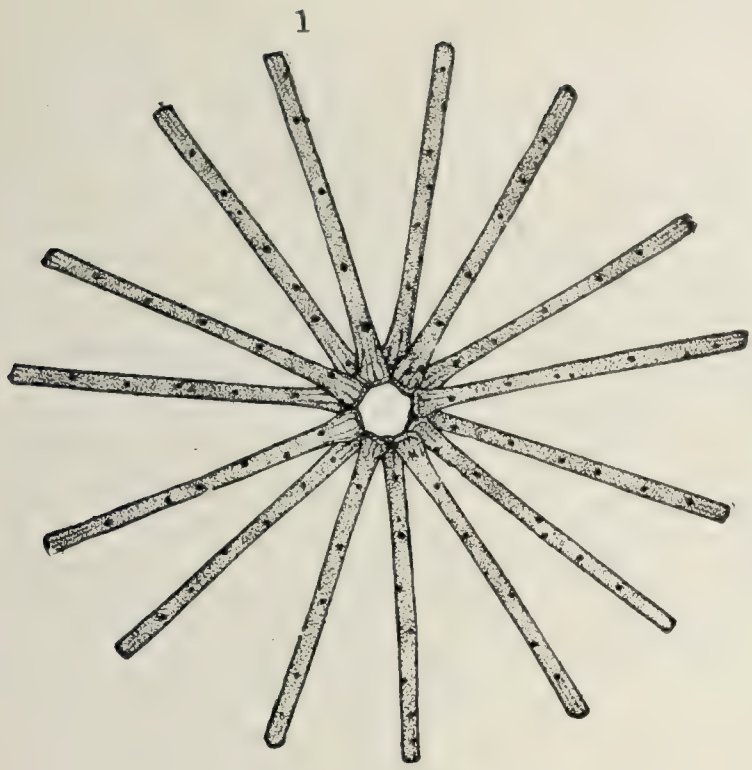


FIG. 20.—Sedgwick-Rafter Graduated Filter. (After Whipple.)

By far the most important service that the microscopic examination renders is that of explaining the cause of the taste and odor of a water, and of its color and turbidity. Several of the microscopic organisms give rise to objectionable odors in water and, when sufficiently abundant, have a marked influence on its color. They also make the water turbid and cause unsightly scums and sediments to form. Upon all such matters relating to the æsthetic qualities of a water the microscopical examination is almost the only means of obtaining reliable information.

The nature of the suspended matter was formerly determined by an examination of the sediment, usually after boiling, which settled out on standing. This crude procedure

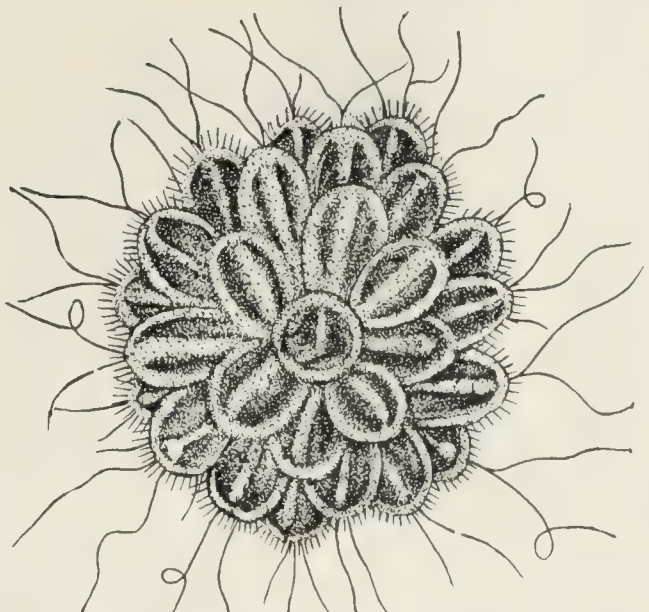
PLATE V.

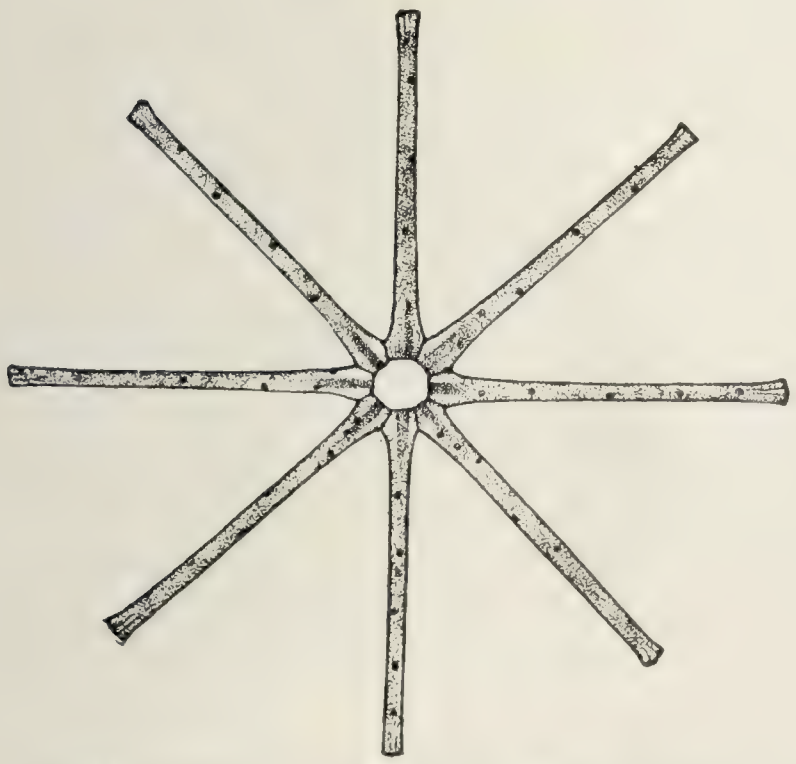






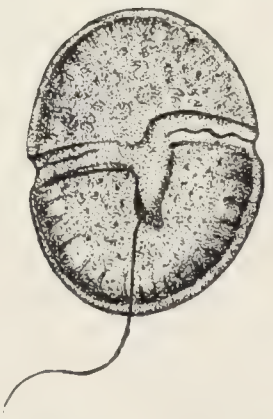












COMMONER AND MORE IMPORTANT FORMS OF MICROSCOPIC LIFE IN WATER.

1, Asterionella, showing rapid multiplication. (Much enlarged.)
2. Peridinium. (× 500.)
3. Macrobiotius. (× 250.)
4. Crenothrix. (A) Filament enclosed in sheath. (B) Sheath removed to show spores. (Much enlarged.)
5. Synura. (× 500.)
6. Asterionella, typical form.
7. Leptothrix. (Much enlarged.)
8. Cypris. (× 25.)
9. Glenodinium. (× 500.)

is now superseded by more scientific methods, the Sedgwick-Rafter method being the one most commonly employed. Briefly, this operation consists of the filtration of a measured quantity of the water sample through a layer of sand upon which the organisms are detained; the separation of the organisms from the sand by washing with a small measured quantity of filtered or distilled water and by decanting; the microscopical examination of a portion of the decanted fluid; the enumeration of the organisms found therein and the calculation from this of the number of organisms in the samples of water examined. A small amount of apparatus is necessary, this including a filter, the decantation tubes, the cell and a microscope fitted with an ocular micrometer. This method is usually numerically precise within 10 per cent., the accuracy of the apparatus depending greatly upon the character of the organisms in the water examined.

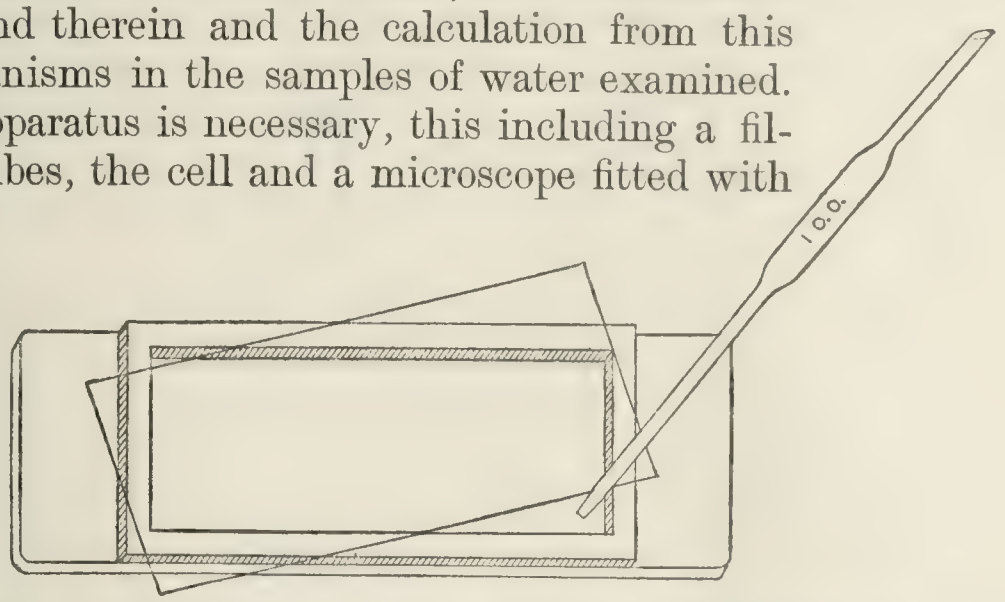


FIG. 21.—Sedgwick-Rafter Counting Cell, showing method of filling. (After Whipple.)

So many are the objects in water that the observer will usually be much at a loss, first, to identify them, and second, to know what their presence implies. Whipple states that, as regards the microscopic life in water, no less than 186 genera have been recorded, of which 108 are plants and 78 animals. Among these, however, only 18 are commonly found in large numbers—13 plants and 5 animals. Of the remainder, 21 are occasionally found in large numbers, 16 plants and 5 animals. More than one-half of the total number of genera are only occasionally or rarely observed. Most of them find polluted water to be unfavorable to their existence, and a microscopic examination of sewage reveals few of the living organisms found ordinarily in water; among those more likely to occur in such surroundings being the ciliated infusoria, as Paramæcium and Trachelocerca; and fungus forms, such as the moulds, Leptomitus, Leptothrix and Beggiatoa. A number of forms exert a powerful influence on the occurrence of odors in water. These are commonly due to their death and putrefaction; but such odors may frequently be brought about by the natural odors of the essential oils generated within the cell-structure of these growths. These oil globules are especially abundant in the mature organisms, and the odors become most pronounced when the breaking up of these organisms liberates the oil globules throughout the water. Among the forms chiefly concerned in the production of unpleasant odors in water may be mentioned Synura, Asterionella, Uroglena, Peridinium and Glenodinium.

In the military service it is obvious that the microscopic examination of drinking-water will not usually be required.

THE BACTERIOLOGICAL EXAMINATION OF WATER.

When the magnitude of the bacteriological field is taken into consideration it is seen to be clearly out of the question, in a work of this special character, to go beyond a simple enumeration of such bacteria as may be present in a sample of water to be examined; leaving the difficult problem of differentiation to be discussed by writers on bacteriology, to whose works the investigator in the higher branches of water examination will presumably have access. There may, however, be instances when a partial bacteriological examination of water will be of value to the military sanitarian —a possibility which serves as the reason for the insertion of the following outline of the methods to be employed.

As the whole success of any bacteriological observation depends primarily upon the sterilization of the apparatus and materials employed, and upon the proper preparation of culture media, great care is naturally to be given to these points. Empty glassware is best sterilized by exposure to dry heat at a temperature of 180° to 200° C. for the period of one hour. The small pipettes used for the measurement of water should be plugged with cotton at the end which is to be placed in the mouth; the whole pipette should then be placed in a suitable glass tube containing a cotton plug in its open end, the large end of the pipette being permitted to protrude through this plug. After being thus prepared the pipettes are sterilized and maintained so in stock.

The culture medium commonly employed in the bacteriological examination of water is that of gelatin-peptone, best prepared as follows: One pound of lean beef, finely minced, is infused with 1 liter of cold water and allowed to stand for twenty-four hours in a cold place or ice-box. The whole mass is then strained through linen and its original bulk made up with distilled water. To this clear filtrate is now added 100 gm. of gelatin, 10 gm. of dry peptone and 5 gm. of common salt; after which the whole is placed in a steam sterilizer for about an hour until a complete solution of the gelatin and peptone has taken place. The resulting liquid will be found to have an acid reaction; this should be carefully treated with a solution of sodium carbonate until only faintly acid.

The bulk of available evidence points to an acid reaction of + 1.5 as the optimum degree of reaction in inoculated culture media; this degree of acidity being present when 1.5 per cent. of normal sodium hydroxide solution exactly suffices to render the culture medium neutral to phenolphthalein.

This liquid is then clarified by mixing with it the whites of three eggs, the whole being again placed in the sterilizer for half an hour. Owing to the coagulation of the albumen this rises to the surface, carrying with it any suspended particles. The whole is then again strained through linen until a clear and limpid liquid is obtained; the liquid then being filtered, with the use of the hot-water funnel, into sterilized test-tubes, placing about 10 c.c. in each tube. The plugs of sterilized cotton with which the test tubes are provided are replaced as each test-tube is filled; the partially filled tubes being at once steamed in an Arnold's sterilizer for fifteen minutes, and this operation being repeated on the two following days to

PLATE VI.



COMMONER AND MORE IMPORTANT FORMS OF MICROSCOPIC LIFE IN WATER.

1. Diaptomus. (× 25.)
2. Cladothrix, showing false branching. (Much enlarged.)
3. Beggiatoa. (Much enlarged.)
4. Daphnia. (× 25.)
5. Cyclops. (× 25.)
6. Bosmina. (× 25.)
7. Anguillula. (× 100.)
8. Uroglena. (× 250.)
9. Canthocamptus. (× 25.)

sterilize their contents. Gelatin tubes thus prepared should be kept stored in the dark, their wool stoppers being covered by rubber caps to prevent evaporation and concentration. Gelatin-peptone should be made in but small quantities, since old jelly has a tendency to become acid in reaction, which is unfavorable to the growth of certain forms of bacterial life.

It is obvious that bacteriological examination of water is valueless unless made promptly upon samples which have been collected with every precaution against contamination. Multiplication of bacteria goes on with extraordinary rapidity at ordinary temperatures, and when possible, the inoculation of culture media should be performed at the source from which the water is drawn. This can be done by the use of Miquel's conical flasks, which have flat bottoms and tubulated glass caps, ground at the joint, plugged with cotton. Such flasks receive 10 c.c. each of the nutrient gelatin when it is first made, and are kept in stock like test tubes. Taken to the field, they receive an inoculation of 1 c.c. of water, and the chances of later contamination by transfer, and of multiplication during the journey to the laboratory, are thereby avoided. Water samples are taken by many in small glass bulbs with long thin stems. These bulbs can be sterilized by the direct Bunsen flame and sealed while hot. Upon afterward breaking off the point of the stem under water, the latter will enter the vessel because of the partial vacuum and the stem can be at once sealed in a candle flame. During transportation to the laboratory the bulbs filled with water samples should be packed in ice. Upon arrival at the laboratory the base of the stem is partially cut through and broken off. After agitation of the water, 1 c.c. is transferred, by means of a sterilized pipette, to a test tube of nutrient gelatin, the jelly having previously been liquefied by immersion of the tube in warm water and the cotton plug having been singed in the Bunsen flame. Mixing of the water and gelatin is accomplished by tilting the tube forward and back, and the mixture is then poured into a sterilized Petri dish, and incubated, in the dark, at a temperature of about 22° C.

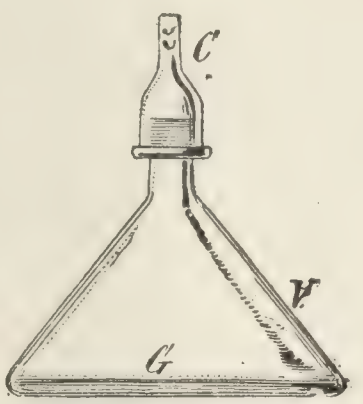


FIG. 22.—Miquel's Flask.

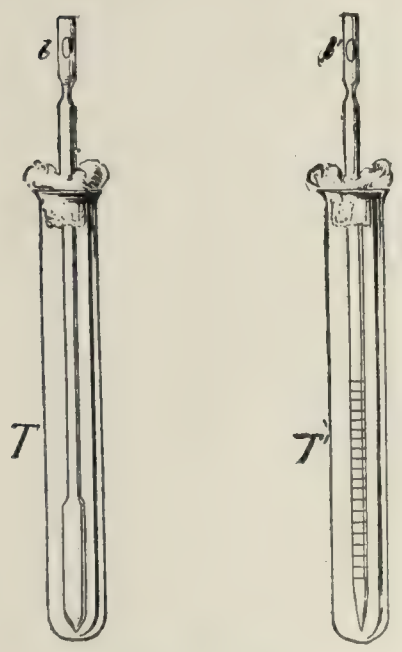


FIG. 23.—Bulbs for Water Samples.

Where the water contains a large number of micro-organisms it is advisable to make several cultures with different dilutions. This is usually accomplished by sowing one tube of nutrient gelatin, for purposes of comparison, in the manner already given. Inoculations are then made in the same manner from a mixture made up of 1 c.c. of the water under examination and 9 c.c. of sterilized water; and also from a mixture containing 1 c.c. of the water sample and 99 c.c. of sterilized water. These dilutions must be made with great care, since any error is multiplied.

Counting of the colonies of bacteria is usually undertaken after an incubation period of forty-eight hours, but this period varies according as there is greater or less danger of the colonies coalescing and thus confus-

ing the count. It is assumed that each colony is the result of the development of a single micro-organism, and from the enumeration of these colonies the amount of bacterial life in each cubic centimeter—taking the various dilutions of the water sample into consideration—may readily be determined. It is the practice of some to use high dilutions, to continue the incubation for a period of two or three weeks to allow the development of the more slowly developing bacteria and to count only such colonies as are then perceptible to the naked eye. This method of procedure has many advantages. Where the number of colonies is large, counting must be done with the aid of a ruled glass plate. For this purpose a modification of Wolffhügel's apparatus is recommended by Mason.

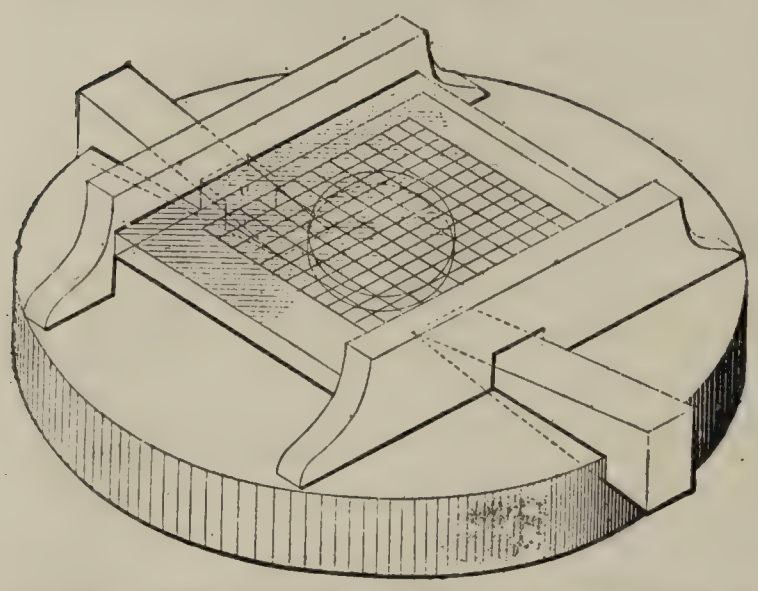


FIG. 24.—Improved Apparatus for Counting Colonies of Bacteria. (After Mason.)

The number of micro-organisms found in different water samples varies greatly, not only according to their degrees of purity but also according to season and, as intimated above, the length of time they have been kept before examination. It is difficult to lay down any standard of bacterial purity for drinking-water, in terms of permissible numbers, as the power of micro-organisms for evil plainly depends not so much upon their quantity as upon their special character. "It has been asserted that the presence of a large number of micro-organisms is no criterion of the quality of a water, and that the mere enumeration of colonies is of little or no value. Without a thorough knowledge of all the accompanying conditions such knowledge is certainly insufficient; though speaking in a general way, it may be accepted that numerous bacteria indicate the existence of a sufficient quantity of food which, in water, is commonly of the nature of sewage."

Besides the positive evidence which it gives regarding the conditions favorable to the existence of germ life in water, pathogenic as well as saprophytic, the bacteriological examination of water has a special value in testing the efficiency of the Berkefeld filters used in the military service. For this latter purpose the cultivation and count of germs is most valuable and differentiation is a secondary matter; for the assumption is a just one that a filter which removes the harmless bacteria will eliminate the pathogenic varieties as well.

Among natural waters a sample which contains but 100 bacteria per cubic centimeter is usually regarded as very pure, while water containing up to 500 per cubic centimeter is usually classed as good. When containing 500 to 1,000 micro-organisms per cubic centimeter a water may justly be regarded as suspicious; while very impure waters contain from 5,000 to 50,000 germ per cubic centimeter.

III.

PURIFICATION OF DRINKING-WATER.

From the nature of military service it may frequently happen that troops are perforce required to utilize water from certain sources, even though this water be of doubtful or even positively bad character. The improvement in quality of such water is the first duty of the military sanitarian, and the thoroughness with which his efforts to this end are carried out will be faithfully shown by the degree to which water-borne diseases are prevalent among the troops of the command. The general methods by which water is purified in the army—physically, mechanically and chemically—are the same as are employed in civil life; but the special methods of their application are usually quite dissimilar and are controlled by the peculiar conditions prevailing in the military service.

Purification by Physical Means.—The application of heat is undoubtedly the most certain and at the same time ready method of effecting the sterilization of water. All pathogenic micro-organisms are destroyed by boiling; clarification is partially accomplished, and, by the same procedure, calcium carbonate is rendered insoluble through the expulsion of carbonic acid, thus rendering the water softer. Carbon dioxide, however, gives sparkle to water and impresses the palate pleasantly, and where this gas is driven off the taste becomes flat and disagreeable. This loss of sapidity is a serious hindrance to the proper use of boiled water in the military service; since many soldiers, despite all efforts and warning to the contrary, will not hesitate to avoid its use whenever possible—preferring to drink the more palatable but less healthful fluid drawn direct from possibly polluted sources. For this reason, due care should be taken properly to aërate all boiled water; this being accomplished by pouring it from one receptacle into another, by forcing air into it, as with a bicycle pump, or by filtering it through charcoal or clean gravel. In garrison, where abundant facilities are at hand, the boiling of a sufficient supply of drinking-water is readily accomplished, but for marching troops, often limited to the tin cup as a utensil for boiling, it becomes a matter of the greatest difficulty—if not, indeed, impossible of proper execution. In hot climates, also, the problem of cooling such boiled water is by no means simple, and care should be taken lest the effect of boiling be neutralized by the admixture of unboiled water, added to reduce the temperature more rapidly. As a general rule, in hot climates, water should be boiled and canteens filled during the evening, thus insuring a supply of cool water for the following day. Where the water-supply is bad and proper filters are not available it is advisable for marching troops habitually to use weak tea or coffee as a beverage, the employment of a sterile drink being thus insured. During the occurrence of an epidemic of any of the diseases known to be transmitted by the medium of water it should be an invariable rule to boil all water used for drinking purposes.

Distillation, the most effectual method of freeing water from all its impurities, is rarely used in the military service except on board transports and at a few stations in the southwest, where a limited supply is furnished by the ice machines. When properly carried out, all danger of infection

by means of water is removed; but if taken from an unclean source distilled water may nevertheless produce sickness, and it has frequently happened in the naval service that intestinal disturbances have followed the use of water distilled from fluid drawn from foul harbors. In taste, distilled water is flat and disagreeable from the expulsion of dissolved gases, and by many such extremely pure water is supposed to affect digestion unfavorably and even to exert a harmful influence on the cellular elements of the gastro-intestinal tract. These theoretical objections, however, have not been found to exist in practice during the many years in which distilled water has been the usual drink in the naval services of the world. For use on transports the Baird condenser gives the best results, an especial feature of this apparatus being the introduction of steam into the condenser in such a manner as to drag with it a constant and regulated current of air, thereby causing very efficient aëration of the water during the act of condensation. By subsequent filtration and by standing for several hours all disagreeable taste is removed. As furnished from the ice machines of southern posts, distilled water, in addition to its flat taste, often has an oily flavor, and under such circumstances troops endeavor to avoid its use whenever possible. While every effort toward the improvement of quality should be made, it is not too much to say that the use of water from a prohibited source of supply should be considered as conduct prejudicial to good order and military discipline, and be punished as such.

Many more or less elaborate forms of apparatus for the sterilization of water by heat have been devised during the past few years—notably those of Rouart, Kny-Scheerer, Desmaroux, and Maignen—but all are so much inferior to the Waterhouse-Forbes water sterilizer, described below, that they do not require further consideration in this connection.

The principle, action and construction of the Waterhouse-Forbes water sterilizer is given as follows by its inventors:

First. A source of water-supply having a maintained level below that required for causing the water to pass entirely through the apparatus.

Second. The application of heat to a part of the water in the apparatus at the point reached by gravity until ebullition is produced, thereby causing the water to rise and pass on through the remainder of the apparatus.

Third. The transference of the heat from the hot water passing from, to the cold water passing to, the point where the heat is applied.

In order to illustrate easily the action of this principle, reference should be made to the accompanying diagrammatic drawing, 1 showing a water tank with a pipe, 2, through which water enters and is allowed to fill the tank up to the water level *x* and no higher, as it is restrained by the float-operated valve shown in the tank. The water to be treated passes from the tank 1 down through the pipe 3 into the compartment 4 of the heat exchange. Rising in the compartment 4, the water enters the heater 5 and rises in the pipe 6 to the level *x*. Heat is applied to the heater 5 by means of a flame 7, which causes the water to boil over through the pipe 6 into the top of the compartment 8 of the heat exchange. When this compartment has become filled, the water runs off through the orifice 11 of the pipe 10. While passing down through the compartment 8 the heat of the water, which is boiling hot, is transferred, by conduction, through the partition or diaphragm 9, to the cold water passing

up through the other compartment 4; so that the water which has been raised to boiling passes out of the apparatus nearly as cold as that entering the apparatus, while the entering cold water becomes heated as it passes toward the heater and reaches the latter in a very hot condition and nearly at the boiling point. Therefore the only heat to be supplied is that necessary to bring the already heated water to the boiling point, and to cause it to rise above the normal level *x*, boil over through the pipe 6, and so pass on through the remainder of the apparatus to the discharge outlet 11. It will be observed that but little fuel is required to operate this apparatus, for the reason that the heat is conserved and used over and over again, whereas by the ordinary process of boiling water and allowing it to cool off, all the heat which is required for raising the temperature of the water to the boiling point is thrown away. For example, if water is discharged from the Waterhouse-Forbes apparatus 5° higher in temperature than on entering the apparatus, but 5 units of heat are lost for every pound of water treated; whereas by the ordinary method, assuming the water to have an original temperature of 62° F., it must be raised to 212° F. to reach the boiling point, and each pound of water treated, therefore, must have 150 units of heat put into it, all this being lost in cooling. It is apparent, therefore, that the Waterhouse-Forbes system is thirty times more economical in fuel.

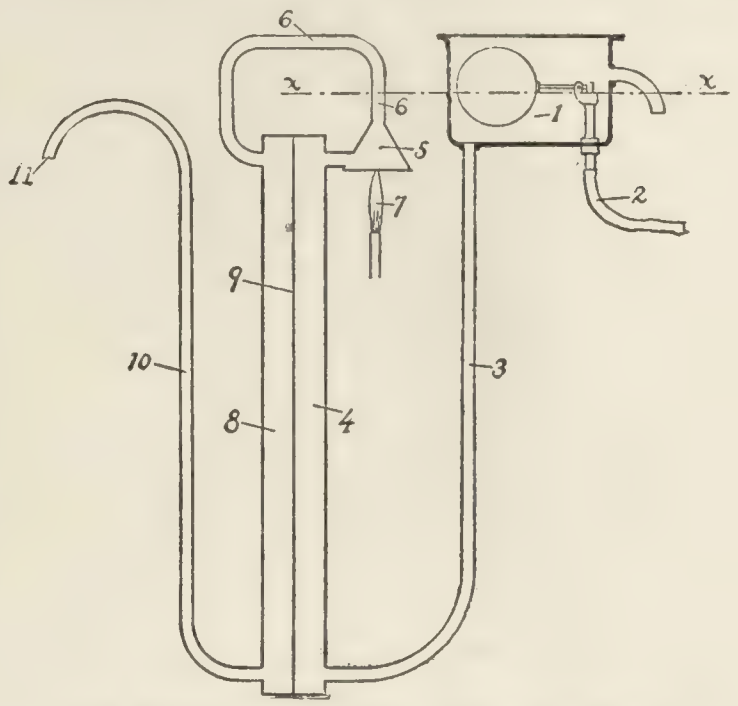


FIG. 25.—Diagram of Forbes Water Sterilizer.

Fig. 26 represents the Waterhouse-Forbes apparatus as first designed for the United States army, the frame of the apparatus being rendered in solid black. A float box or water tank contains a float-actuated valve, which maintains the level of the water at the line *x*, while the figure 2 designates the pipe through which the water is supplied to the float-actuated valve. At 3 is a pipe through which the water passes from the float box to the bottom of the "raw-water compartment;" the first heat exchange being shown by the number 4. Rising from this compartment, the water overflows and runs down through the pipe 5 to the bottom of the "raw-water compartment," 6 of the second heat exchange; and rising through the second compartment, the water flows through the pipe 7 into the heater 8, where it stops by gravity at the level *x*. Heat is applied to the water in the heater by means of an oil stove, 9; the flame being within the wind gauge 10. When ebullition takes place the water rises in the heater and flows over into the basin 11, and from this it runs off through a pipe 12, (Fig. 27, showing "sterilized-water side" of compartment) into the top of the "sterilized-water compartment" 13. When the compartment, 13, and pipe, 14, are filled, the water runs from the pipe into the top of the compartment 15, and when this compartment is filled the water is discharged through the opening 17 of the pipe 16.

Vents are provided at the points 18, 18, 18, 18, to prevent air or vapor trapping the flow of water. Should for any reason the water level in the float box rise above the normal line *x*, the surplus of the water will overflow through the pipes constituting the frame and run off at 19. When the apparatus is in operation boiling-hot water may be obtained if desired by stopping up the orifice 17 of the discharge pipe until the catch basin at 11 overflows at the small spout 20.

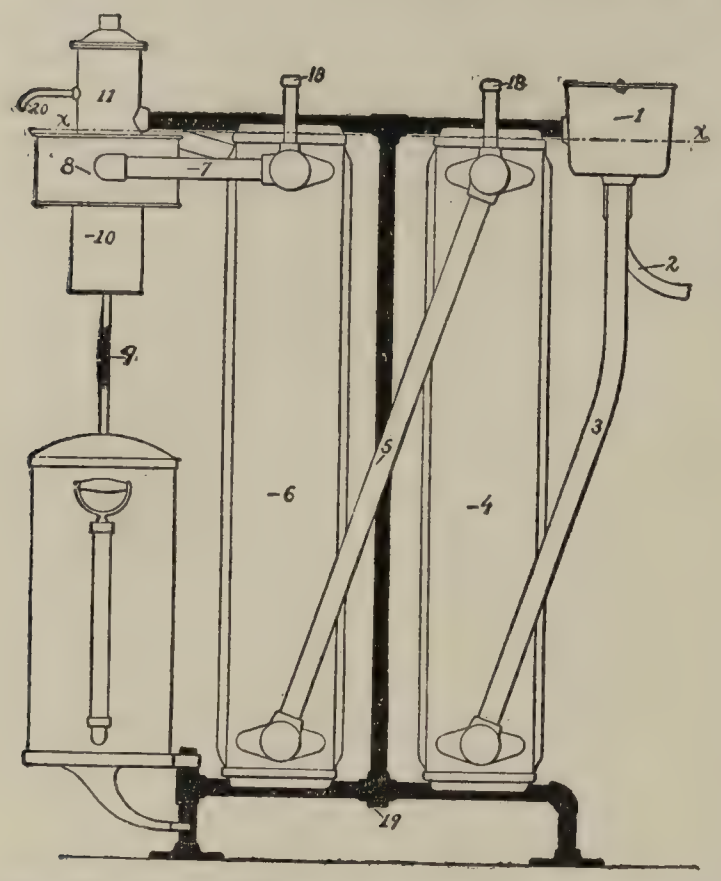


FIG. 26.—Forbes Water Sterilizer. "Raw water" side.

In construction, the apparatus is entirely self-contained and may easily and quickly be assembled for operation or taken apart for transportation. In the latter state the complete apparatus forms five bundles, no one of which weighs more than forty-five pounds. The entire apparatus is throughly galvanized after its construction, thereby insuring a perfect zinc surface throughout. The frame which carries the entire apparatus is of standard one-half inch wrought-iron pipe, connected with malleable iron fittings. The various pipes constituting the frame are easily screwed into the connecting sockets and fittings, and when taken apart for transportation form a bundle of straight pipes, none of which is over four feet in length. The float-box is of cast iron and the float is of well-seasoned white pine, specially treated to prevent water-logging. The float-box is provided with a cover which is removable by unscrewing two bolts.

The circulating pipes, through which the water passes in its course through the apparatus, are of standard three-fourths inch wrought-iron pipes, with special cast-iron fittings. The most important part of the apparatus is the heat exchange, which in this case is divided into two units in order to lessen the weight of any single piece for transportation. Each heat exchange is in the form of a box five and one-half inches square and twenty-six inches long. The box is divided into two water-tight compartments by means of a diaphragm of thin metal. The two half shells forming this box are flanged and riveted on opposite sides and the diaphragm is held between these flanges on either side. Therefore any leaking must occur from the interior of either compartment outward, and it is impossible for a leak to occur from one compartment to the other. The diaphragm is formed of a single sheet of iron three feet wide by eight feet long, folded back and forth into deep corrugations about one-fourth of an inch apart and four and one-half inches deep. The half shells forming the box are of iron, and the whole exchange, both shell and diaphragm, is formed from the black iron and riveted together. In the process of galvanizing, the entire surface of the metal is not only thoroughly coated with zinc, but at the same time all the joints are entirely closed with zinc and the whole

made absolutely water-tight. The heads or ends of the exchange are cast into the exchange of solid metal for a depth of one-half inch, thereby not only preventing external leaking but also preventing any leak from one compartment to the other. The ends are further covered with a casting which serves to hold the exchange in its proper place in the frame of the apparatus. The heater is in the form of a flat cone having a rolled steel bottom upon which the frame impinges. From the top of the cone rises a short small pipe. It is within this pipe that the water rises by gravity and stops several inches below the top of the pipe. The top orifice of this "fountain pipe" is several inches above the bottom of the catch basin, so that any water that boils up through the "fountain pipe" overflows and is caught in this basin, and cannot run back into the heater but must flow out through the pipe 12. The heater is heavily insulated to prevent the loss of heat by radiation. The oil stove is constructed to burn kerosene, and the oil is fed to the burner by air pressure generated by the pump. The oil before burning is made into vapor which burns with a hot, blue flame, leaving no soot or deposit on the heating surface of the water heater.

On examination of this apparatus by a board of medical officers it was found that water heavily charged with the typhoid bacillus, the colon bacillus or the bacillus prodigiosus was rendered entirely free from living organisms. Agar plates made with 1 c.c. of water which had passed through the apparatus showed an average of six colonies of spore-bearing bacteria, such as the hay bacillus or the bacillus ramosus. The capacity of the apparatus was found by the board to be at the rate of three hundred and twelve gallons in twelve hours; there being a difference in temperature of but 4.5° F. between the non-sterilized and sterilized water. Careful tests show that there is no apparent loss of the natural gases during the passage of the water through the apparatus, and that it is free from lead or other substances which might have entered into solution from the alloy used for holding the diaphragm in place. The weight of this water sterilizer is one hundred and fifty pounds, divided as follows:

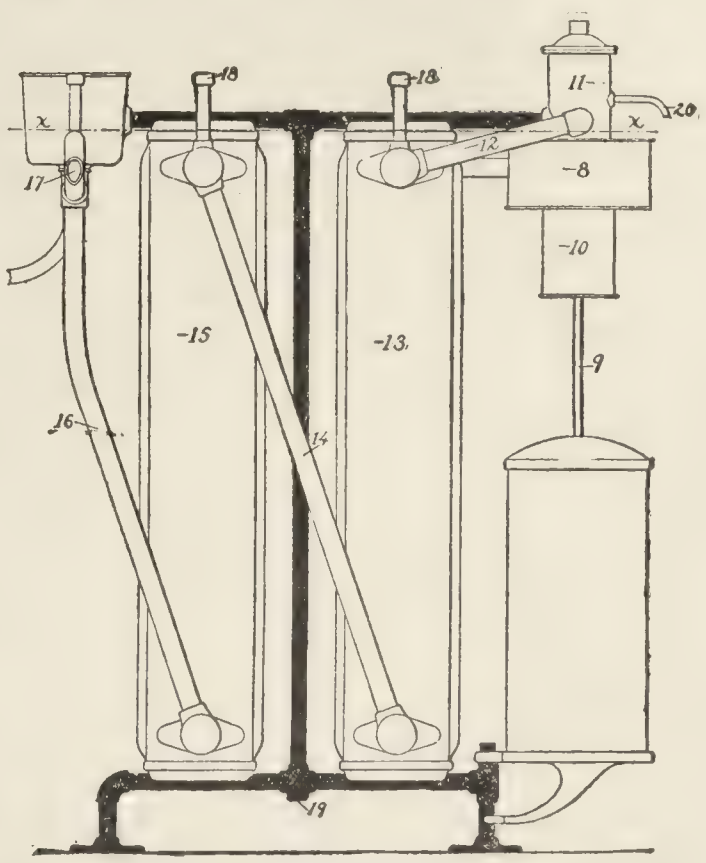


FIG. 27.—Forbes Water Sterilizer. Sterilized water side.

	Pounds.
Two heat exchanges, each forty-three and one-half pounds	87
Two frame supports, each two pounds	4
Frame	8
Float box, complete	11
Four flow pipes, with connections	20
Heater	10
Oil tank and burner, complete	10
Total	150

It will thus be seen that this apparatus is quite transportable aud can be entirely taken apart and made into either four or five bundles, no one of which will exceed forty-three and one-half pounds in weight. Two such sterilizers may be carried on a pack mule.

The advantages of this most ingenious water sterilizer were summed up by the board as follows:

First. That water passing through it, although brought to the boiling point, is maintained at this temperature for so short a time as not to be deprived of its natural gases, and hence not rendered unacceptable to the taste.

Second. That all living micro-organisms, except a few spore-bearing bacteria, are destroyed by the degree of heat attained during the passage of the water through the apparatus. The disadvantage of the escape of a few spore-forming bacteria through this apparatus is considered to be of no practical importance.

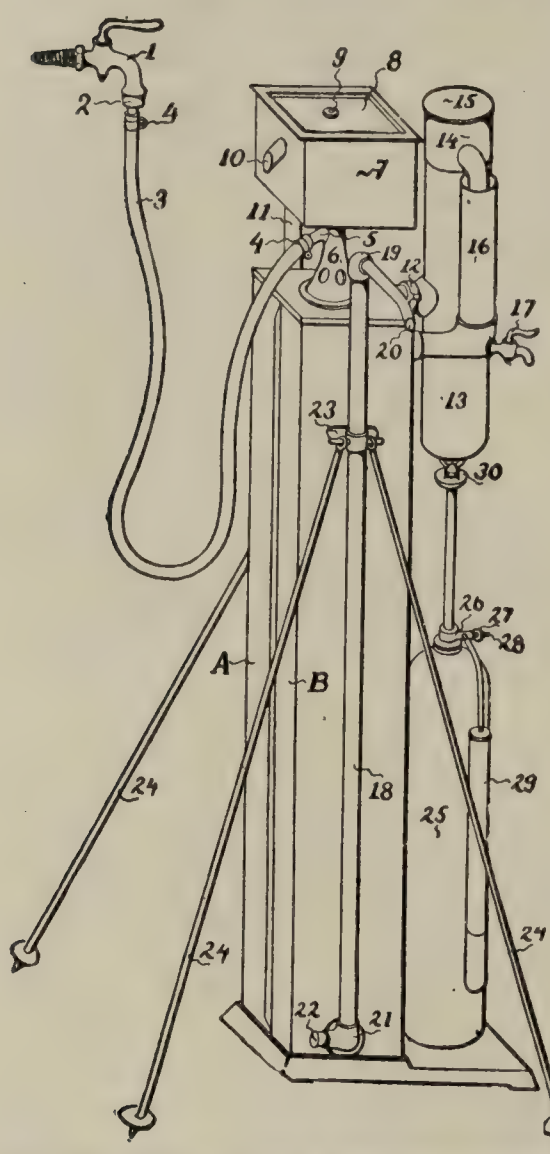


FIG. 28.—Forbes Water Sterilizer, Specially Designed for Field Use.

Third. It furnishes an abundant supply of practically sterile water and may be kept in action, if necessary, for the entire twenty-four hours without renewing the supply of oil in the reservoir, and at a cost of about four cents an hour.

Fourth. The water, having been slowly heated until it reaches, temporarily, the boiling point, is afterward cooled to within 4.5° F. of the water entering the apparatus. This is one of the most important advantages possessed by this sterilizer. By placing the bottom of the exchange in a freezing mixture, the temperature of the sterilized water, as it flows from the machine, may be reduced below 40° F.

Fifth. Its durability and freedom from liability to breakage.

Sixth. The facility with which the apparatus may be put together and entirely taken apart, only one tool—a wrench—being required for this purpose.

Seventh. The facility with which the apparatus can be thoroughly cleansed. This is effected by the removal of the side pipes, thus permitting a complete flushing out of both exchanges.

The fact that the apparatus does not clarify the water was deemed of no particular importance by the board, since this could be easily effected prior to its passage through the sterilizer by means of one or two water barrels partially filled with fine and coarse sand and placed at the proper height above the sterilizer.

The board was of the opinion that a single apparatus would suffice for the needs of two companies; or, where storage of water was possible, of a battalion. As a result of exhaustive experiments the Waterhouse-Forbes apparatus was officially recommended as being superior to any of the many

filters or water sterilizers submitted for trial by the board and as being well suited for the abundant supply of sterile water to troops.

An improved apparatus, made of brass lined with block tin, has recently been devised by the same company especially for the use of troops in the field. This apparatus is very transportable. Its weight, when boxed for shipment, is only about ninety pounds and the volume of the case only 3.9 cubic feet, making a package forty-nine inches in length. In the illustartion of this improved sterilizer on page 142, 1 is a stop cock intended to be screwed into a barrel, hogshead or other retainer for "raw" water, near the bottom of same; 2 is a coupling for connecting the rubber hose 3 with the stop cock; 4 and 4 are hose bands; 5 is a nozzle for admitting water to the apparatus. This nozzle is cast in one piece with the pedestal, 6, forming a support for the float box 7; 10 is an overflow for the float box. The function of the float box 7 and its internal members is to maintain the proper level of the "raw" water supplied to the apparatus. The overflow 10 is below the tops of the tubes 35, so that any excess of water entering the apparatus, through accident or failure of the valve, 38, will overflow through it and render it impossible for raw water to pass through the sterilizer.

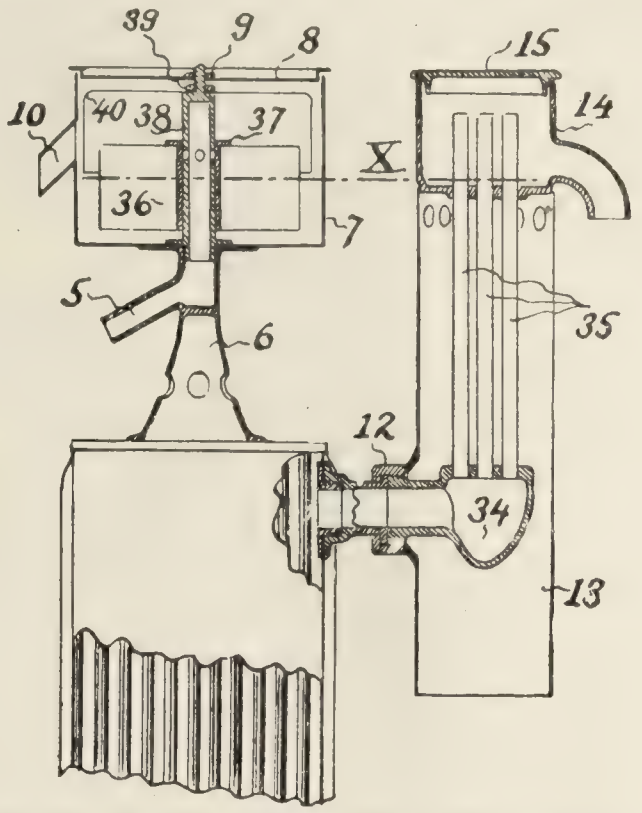


FIG. 29.—Partial Sectional View of Forbes Field Water Sterilizer, Giving Detail of Upper Part of Heat Exchange, Float Box and Water Heater.

The valve mechanism in this apparatus operates to maintain a uniform water level regardless of the pressure existing in the source of supply, and it is therefore applicable for use when being fed from a barrel without pressure, as in the field, or in a barracks where the water is under considerable pressure from a pipe line.

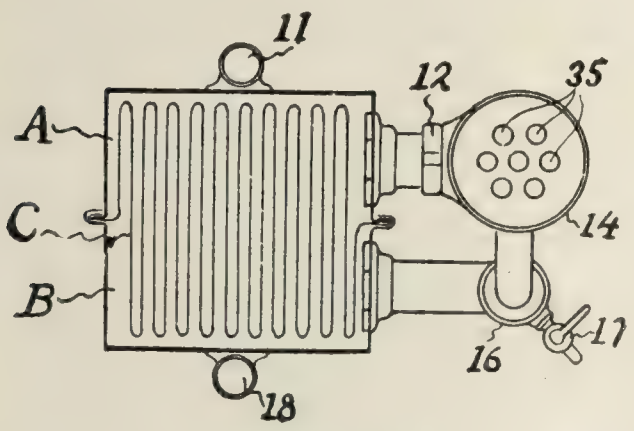


FIG. 30.—Top Sectional View of Forbes Field Apparatus, Showing the Method of Dividing the Raw and Sterilized Water.

Heat is generated by the combustion of mineral oil, one quart of the latter being sufficient for five hours' continuous use; while the oil reservoir contains sufficient fuel to operate the apparatus continuously for twenty-four hours. The capacity of the field apparatus is ordinarily about twenty-five gallons per hour. The difference in temperature between the incoming and outgoing water is much greater than in the previously described apparatus, which possesses two heat exchanges, amounting to as much as 15° to 20°. This fault, however, is by no means serious and is much more than counterbalanced by the greatly increased portability of the new apparatus.

Purification by Mechanical Means.—Sedimentation is practiced at nearly all military posts or encampments in which the water supply is

derived from running streams, usually by impounding the water by dams, or sometimes, as at Fort Ringgold, by the use of special sedimenting reservoirs. The process very materially improves the character of a turbid

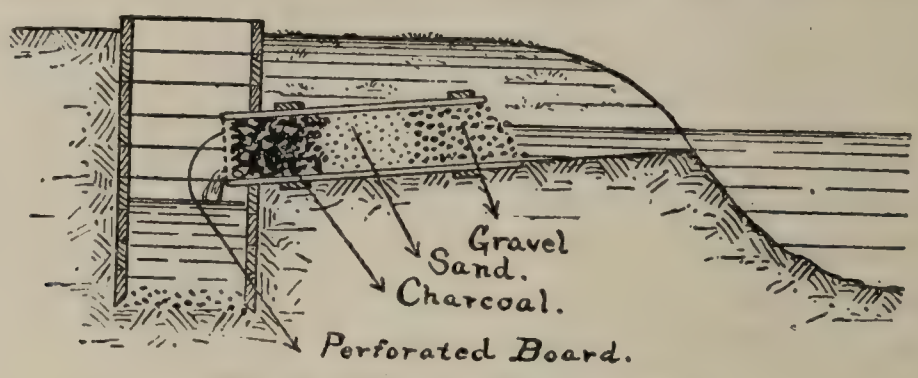


FIG. 31.—Improvised Camp Filter.

water through the deposition of a considerable proportion of the suspended matter.

Theoretically, by the process of filtration, water must not only be rendered clear and free from sedimentary deposits, but also, when taken from a doubtful source, it should be freed from any infectious material which may have gained access to it. The clarification of a turbid water is, from a sanitary standpoint, of little importance as compared with the removal of disease-producing germs; but the palatability of such water is certainly increased by the process, and the destruction of the contained bacterial life may be subsequently accomplished by other means. Filtration, even of a crude nature, improves the potability of water through removal of the grosser particles held in suspension; but care should be taken lest clarification and sterilization be confused, and the operation be regarded as satisfactorily completed when but the former is accomplished. It is most important that the filtering material employed be clean and frequently renewed, else it may soon happen that fairly pure water, after being passed through an illy-tended filter, may contain far more micro-organisms than were present prior to filtration.

Improvised Filters.—In the field it is often necessary to improvise filters, but such filters serve only to clarify water and do not remove micro-

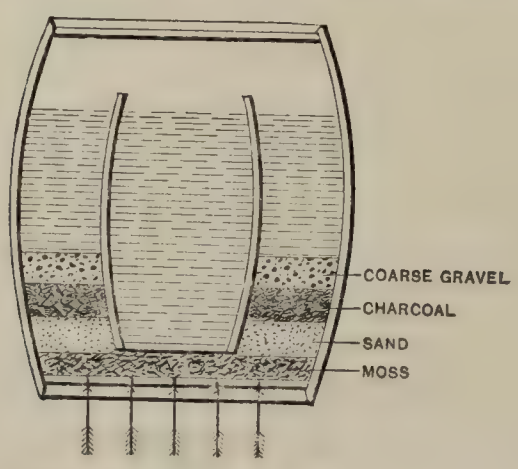


FIG. 32.—Barrel Filter.

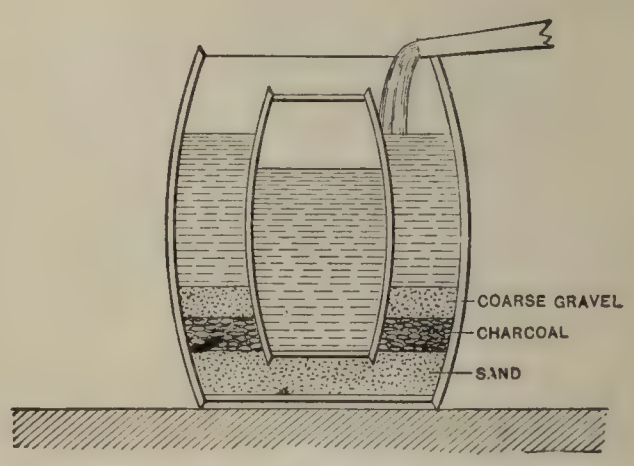


FIG. 33.—Barrel Filter.

organisms. After clarification, the water should be sterilized by other means, preferably by boiling.

The simplest way of accomplishing hasty filtration consists in digging a pit near the proposed source of supply, so that the water may percolate through the soil before being used. A more satisfactory method consists

in sinking a barrel or box in such a pit and allowing water to pass in through a wooden trough packed with clean sand, gravel or charcoal. If two boxes or barrels of unequal size be available, one may be placed inside the other and the interspace filled with clean sand or suitable filtering material. The outer barrel is pierced by small holes near the bottom and the inner barrel near the top, the whole being partially submerged in the water to be filtered.

Where the water supply is smaller this method may be reversed, the space between the barrels being partially filled with filtering material and the bottom of the inner barrel being removed or, better, perforated. Water is then poured in above the filtering material, whence it percolates downward and rises to its proper level in the inner barrel.

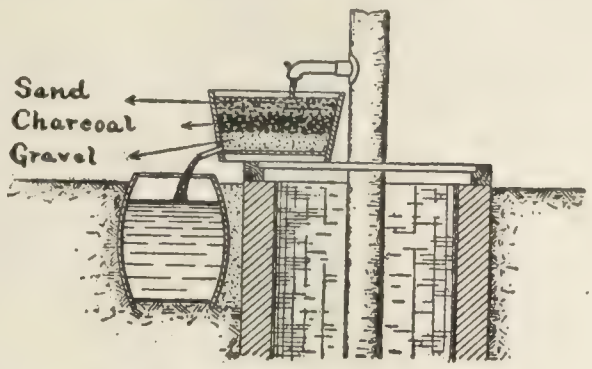


FIG. 34.—Barrel or Tub Filter.

An effective filtering arrangement may be improvised by boring a small hole near the bottom of a suitable receptacle and partially filling the latter with layers of sand, gravel and, if obtainable, charcoal. The water to be clarified is poured in at the top, passes through the filtering medium and is collected as it emerges from the aperture below.

Should a large box be at hand it may be made to serve both for the filtration and storage of water by dividing it into four compartments by suitably pierced partitions. Two of these spaces are partially filled with sand, charcoal and gravel, or small pebbles, the muddy water being poured in a chamber at one extremity and, after being twice filtered, removed by a spigot at the other end. This method is perhaps the best for securing improvised filtration, but is open to the practical difficulty of making the partitions sufficiently tight to prevent the possibility of a leakage of unfiltered water from one compartment into another.

It should be borne in mind that filters of the above character are but temporary makeshifts at best, and that, unless the filtering material is fre-

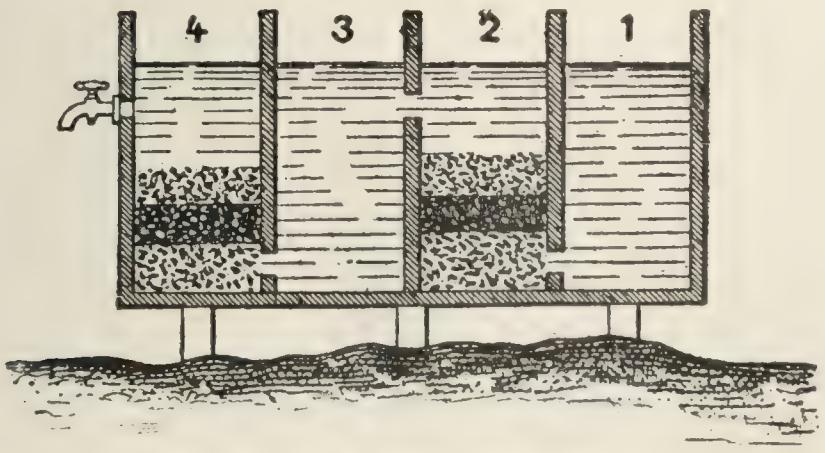


FIG. 35.—Box Filter. (After Parkes.)

quently renewed, they become a source of danger through the great amount of germ life which they retain and for the development of which they furnish every facility. It is important that the sand and gravel employed in these improvised filters be thoroughly washed and then sterilized by heating to redness before use. The addition of a small amount of alum

to the water first filtered is of advantage, since it produces a jelly-like precipitate which coats the sand of the filtering surface and materially aids in arresting and entangling the more minute particles held in suspension.

Maignen Filters.—For moving troops or for camp use, as regards the clarification of water, the Maignen filter gives excellent results. The filtered water, however, is not by any means sterile, although a certain proportion of existing micro-organisms is undoubtedly removed by such filtration. Hence water clarified by passing through this type of filter requires to be sterilized by further procedure before use. The rapidity of filtration, however, is great, and cleanliness of the apparatus is easy to maintain. Further, this filter possesses the great military advantage of being durable, light and readily portable. When used as supplementary to the Berkefeld or Chamberland apparatus the Maignen filter is of great utility.



FIG. 36.—Core of Maignen Filter.

These filters are made in many forms, though varying but little in the essentials of construction, as shown in the accompanying illustration. There is a central core of asbestos felted cloth, surrounded by a layer of charcoal or charcoal compound. In the British army a modified Maignen filter, using a mixture of alum, iron and charcoal, under the name of "Carferal," is employed. The charcoal layer is held in place by an outer asbestos covering of one or more thicknesses. The operation of filtration is simple and is performed by siphonage—it being readily appreciated that the rapidity of filtration will be largely dependent on the length of the lower branch of the siphon. Where very muddy water is being clarified the filtering organ should be frequently sponged — not brushed — or washed in clean water. When not in use it should be cleaned and allowed to dry in the sun.

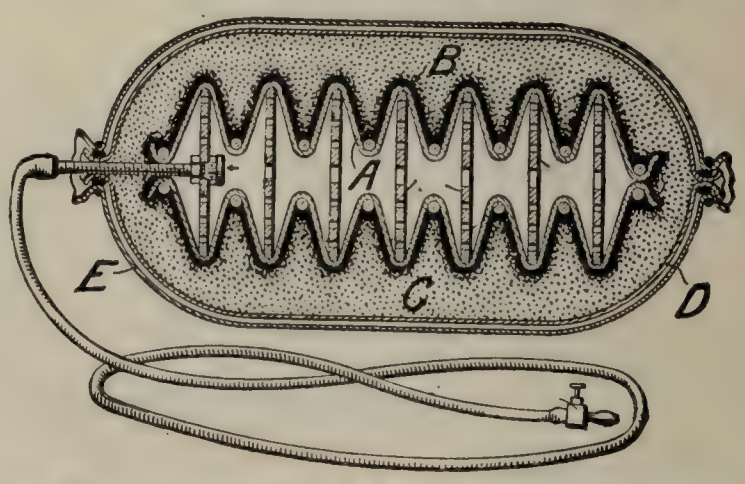


FIG. 37.—Cross Section of a Maignen Filtering Organ. *A*, Inner asbestos cloth; *B*, layer of fine "Carbo-Calcis"; *C*, layer of granular "Carbo-Calcis"; *D*, outer asbestos cloth; *E*, protective asbestos cloth.

To disinfect the Maignen filter a solution of permanaganate of potash, 1–1,000 strength, may be passed through the apparatus, or the filter may be sterilized by boiling and drying in the open air. The latter operation is not always easy of accomplishment in the field.

Berkefeld Filters.—The essential feature of the Berkefeld filter is a hollow filtering bougie of infusorial earth, composed of minute skeletons

of diatomacæ, and containing, by their ladder-like and interlacing structure, an enormous number of small pores. In a given bulk of the filtering cylinder the solid matter is said to represent only 27 per cent. of the space occupied. The filtering cylinder is closed above, but opens below in a nozzle. This cylinder is enclosed in a strong metal or glass jacket, a space intervening between the two above and at the sides, while below they are fixed together by a screw tap, with an opening in the centre for the passage of the nozzle. The water passes through the bougie from without inward.

The yield of this filter naturally varies with the degree of pressure, the state of the water as regards suspended material and the frequency with which the operation of cleansing is performed. Where the water is turbid the outside of the filter bougie is soon covered with a deposit by which the process of filtration is greatly impeded and ultimately brought to an end;

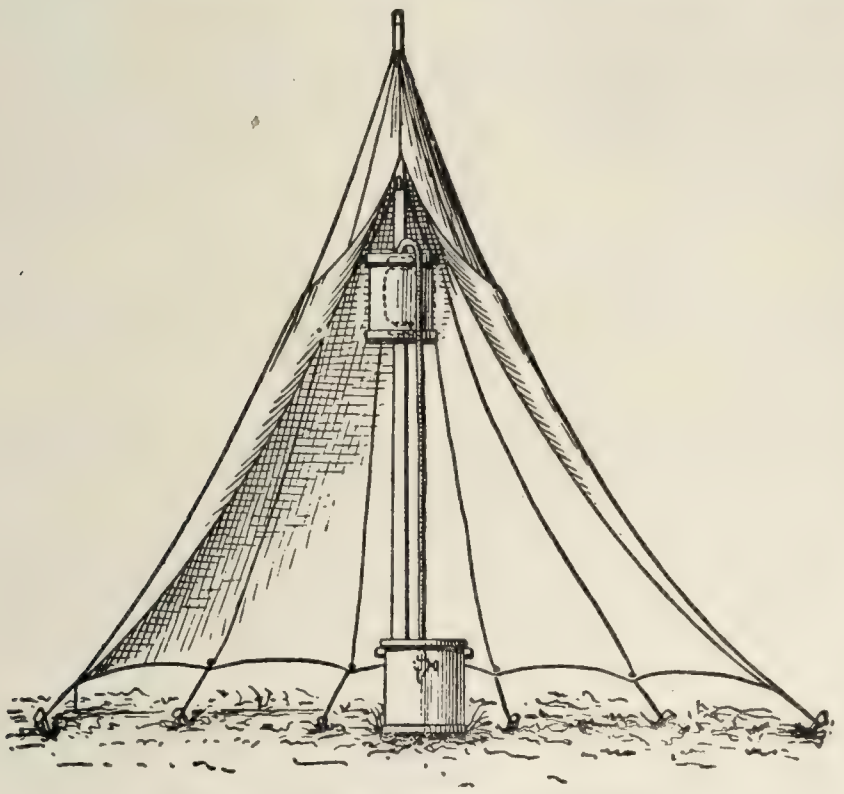


FIG. 38.—Maignen Filter in Operation.

and hence it is essential that muddy water be clarified before being passed through the filter. With a pressure of forty pounds, the yield per minute, at the outset, is as follows:

3	cylinders,	diameter	6	inches	.....	1½ gallons.
5	"	"	7	"	.....	2½ "
9	"	"	8½	"	.....	4½ "
15	"	"	12	"	.....	7½ "

Without proper cleansing, however, the filter soon becomes clogged and the above quantities are markedly reduced.

The bougies are cleansed by brushing or sponging, and it is claimed that with each cleaning about one-thousandth of an inch is removed, thus reopening the pores and preventing clogging. Disinfection of the cylinder is accomplished by boiling, care being taken to avoid injury by sudden changes of temperature. If dropped at once into boiling water the cylinder becomes cracked and useless.

In experiments made by the writer with respect to the sterilization of water by filtration through the Berkefeld portable field filters the results were by no means uniform, a cylinder being occasionally found which did

not arrest all bacterial life. In one case, where the cylinder was apparently sound and free from cracks, 1 c.c. of rather pure unfiltered water yielded sixty-six colonies of bacteria when grown on agar for thirty-six hours, while an equal amount of filtered water gave thirty-one colonies. But usually the water was rendered almost completely sterile after passing through the apparatus, as is well shown in the accompanying illustrations of plate cultures. It would appear from this that all filters should be tested bacteriologically before being issued for use by troops.



FIG. 39.—Filtering Material of Berkefeld Filter, magnified 500 diameters.

Sternberg states that under a twelve-pound pressure no bacteria passed through a Berkefeld filter, attached to a faucet, for twenty-one consecutive days. A board of medical officers, however, has recently found that repeated sterilization by boiling apparently produces structural changes in the bougie by which the passage of micro-organisms ultimately becomes possible. Fragility of the cylinder, leading to breakage from rough handling, is another disadvantage not to be overlooked.

Berkefeld filters, made up in forms especially adapted to field service, are now used in the armies of the United States, England, Germany and Austria. In these military forms the filter usually rests on a double-acting hand pump attached to a folding tripod, the legs of which are so arranged that they can be readily folded for transportation. The dimensions of the

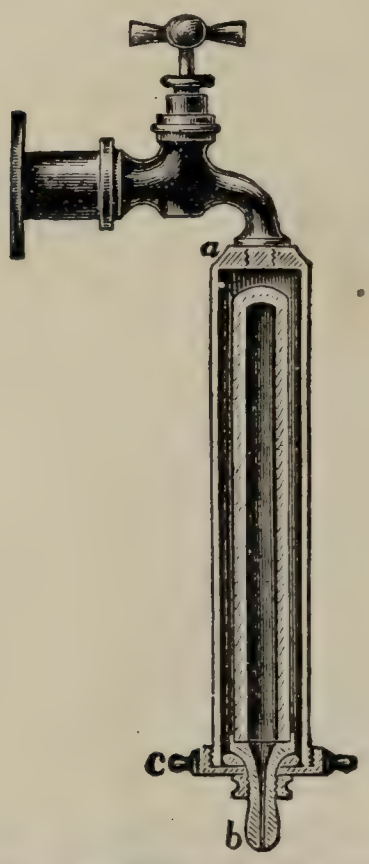


FIG. 40.—Longitudinal Section of Single Berkefeld Filter.

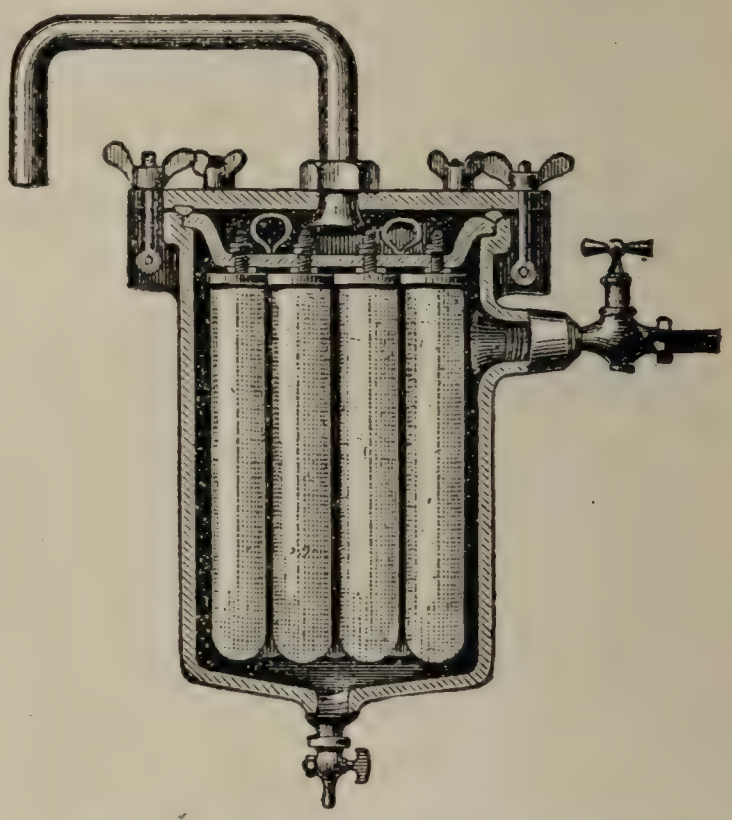
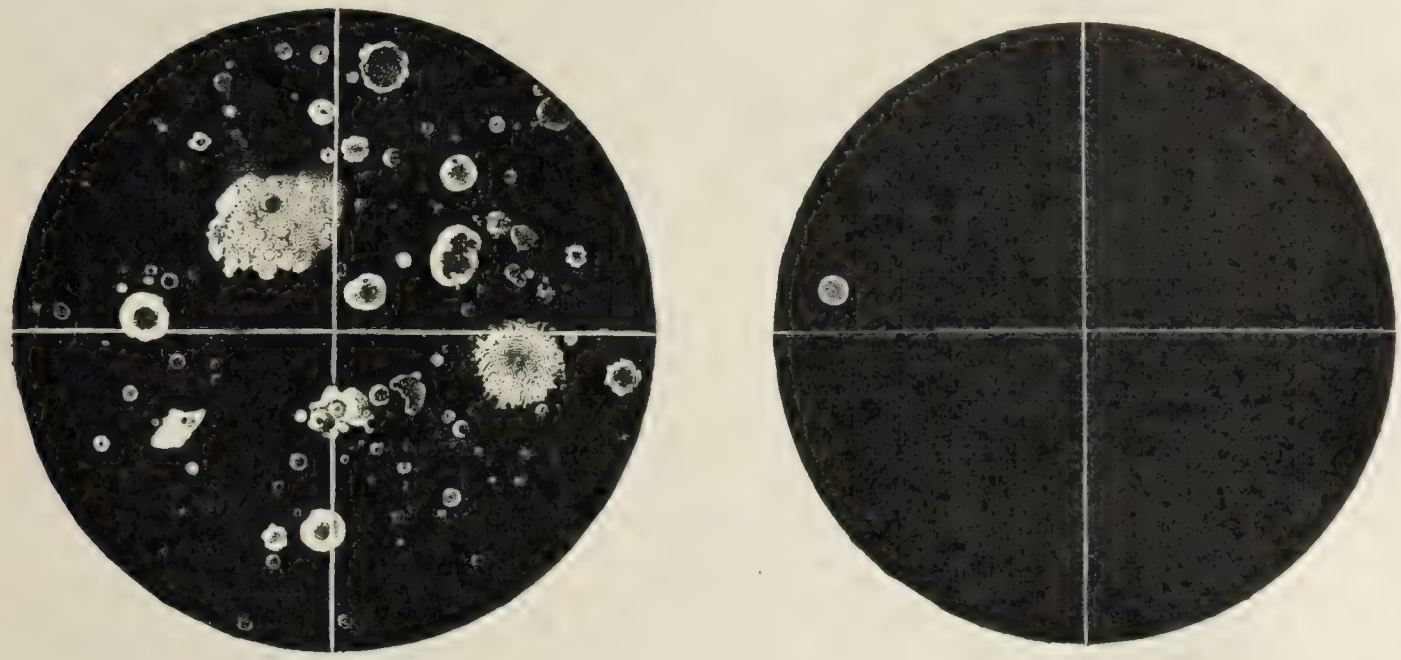


FIG. 41.—Battery of Berkefeld Filters.

apparatus, when folded together, are two feet by seven inches by six inches. The weight is eleven pounds, and the capacity of filtered water is one-half gallon per minute. A small Berkefeld filter, without the tripod attach-

ment, is supplied for hospital use, and is packed in the dressing and sterilizer chest.

A large size Berkefeld filter, containing a battery of nine cylinders, mounted on a substantial wooden frame and intended for carriage on mule-



A. *B.*

FIG. 42.—*A*, Cultures made from 0.5 c.c., very muddy tap-water, without filtration; *B*, cultures made from 1 c.c. of same water after filtration through Berkefeld filter. (Twenty four hours incubation.)

back, is now manufactured. This apparatus is said to supply four and one-half gallons of water, per minute, entirely free from all bacterial life.

Berkefeld filters were much used in our camps during the war with Spain. At Chickamauga they were reported as being easily broken and as sometimes requiring cleansing after the filtration of half a bucket of water. Many bougies were broken by the use of too great force by inexperienced men, and filtration was largely abandoned as a result. The best plan was found to consist in concentrating all the filters of a regiment at some central point and placing them under the supervision of an officer.

Pasteur-Chamberland Filters.—These filters are similar in construction to the Berkefeld apparatus, the chief difference lying in the fact that the filtering cylinder is composed of unglazed porcelain instead of infusorial earth. The yield of these filters is much less than that of the Berkefeld filters; a battery of twelve bougies, under a pressure of seventy pounds, furnishing only about twenty gallons per hour. In the French army, for use in barracks, one bougie

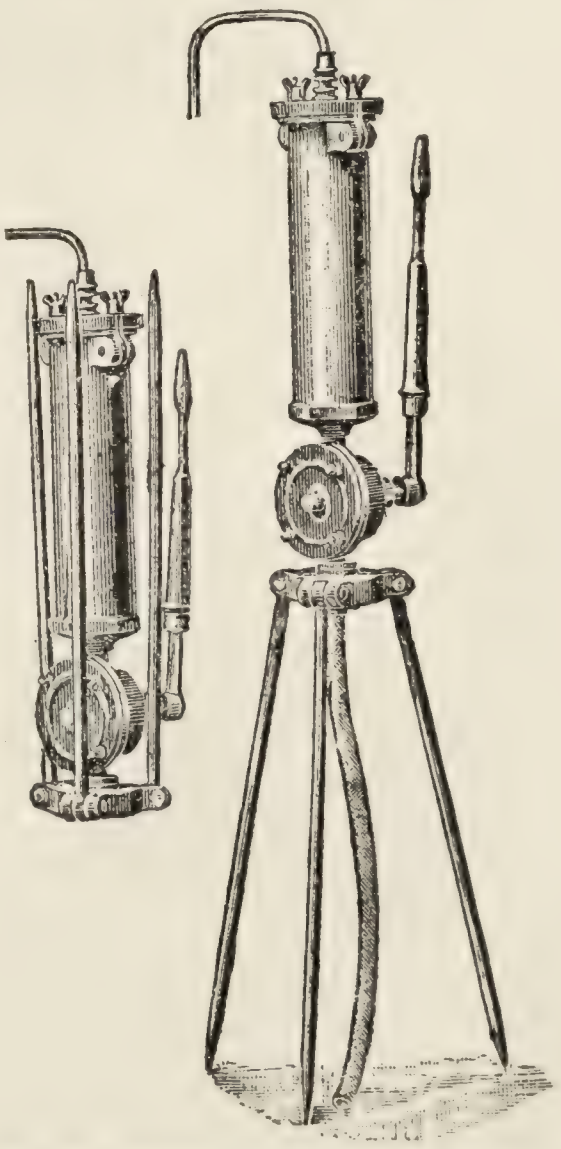


FIG. 43.—Berkefeld Filter for Field Use.

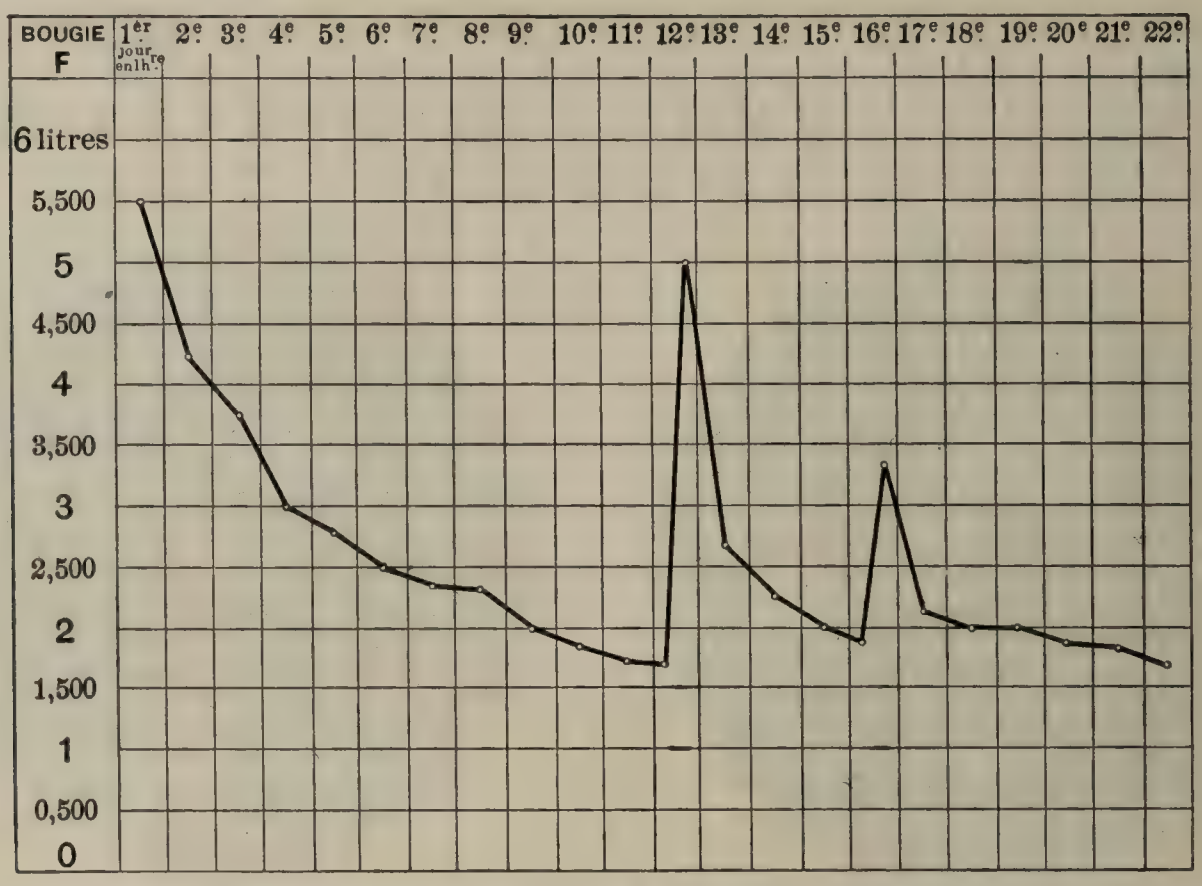


FIG. 44.—Hourly Yield of Pasteur-Chamberland Filters as Affected by Clogging of the Pores. The two subsequent rises indicate the cleansing of the filter. (After Laveran.)

is allowed for each ten men, this being expected to provide about fifty liters of sterile water daily. Clogging of the porcelain occurs rapidly and filtration is accomplished only at the expense of frequent cleansing; this, together with sterilization, being effected in the same way as with the Berkefeld filter.

While sterile water is yielded at the outset it has repeatedly been shown that bacteria appear in the filtrate after a period of about a week. Increased pressure seems to favor the appearance of these micro-organisms, which, however, presumably grow by direct contact rather than are mechanically forced through the filter bougie. It is evident, therefore, that sterilization of the Chamberland and Berkefeld apparatus should be accomplished at least once weekly during use.

The portable Chamberland autoclave filter, as adopted in the French army, weighs about one hundred pounds. The results given by this apparatus, used in Dahomey, in 1892, and later in Madagascar, have not been satisfactory as regards marching troops, although valuable for semi-fixed camps or hospitals. On these expeditions the filters were kept clean with difficulty, proved to be a heavy burden for their bearers, especially where the country was rough and the vegetation dense, and could not supply a sufficient quantity of

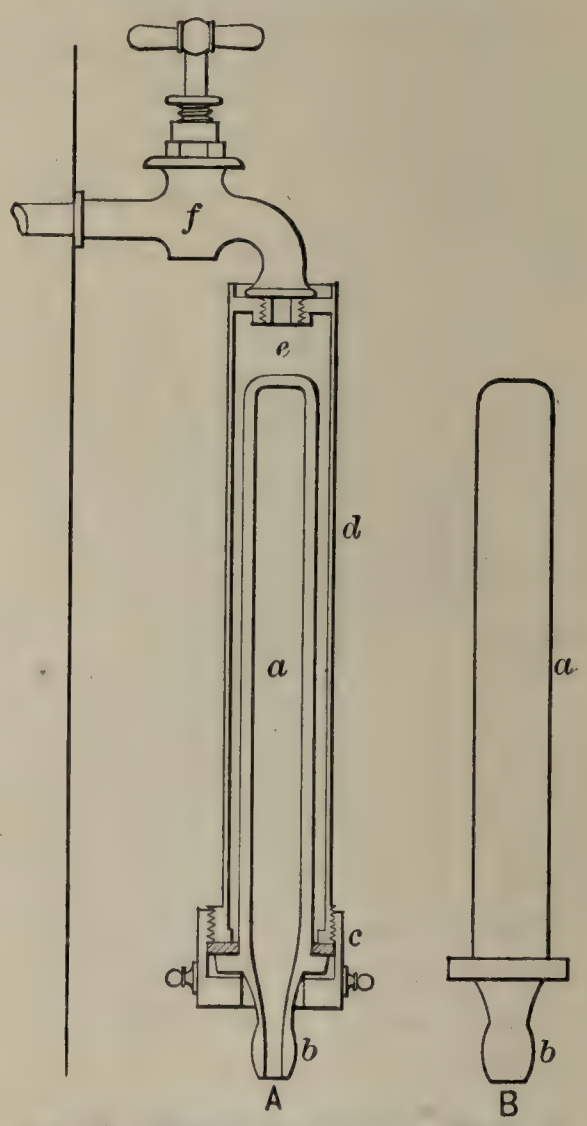


FIG. 45.—Pasteur-Chamberland Filter, in longitudinal section.

filtered water at short notice on the conclusion of the march. In the recent British expedition against the Ashantees, the Pasteur filters were reported as readily clogged and hard to work. Their use was finally abandoned.

Both the Berkefeld and Chamberland filters, if given proper care, serve an excellent purpose in garrison. In the field, especially during active campaign, the former apparatus is undoubtedly much preferable through the greater amount of water it supplies, although by no means without serious defects. The transportation of any apparatus of this character may

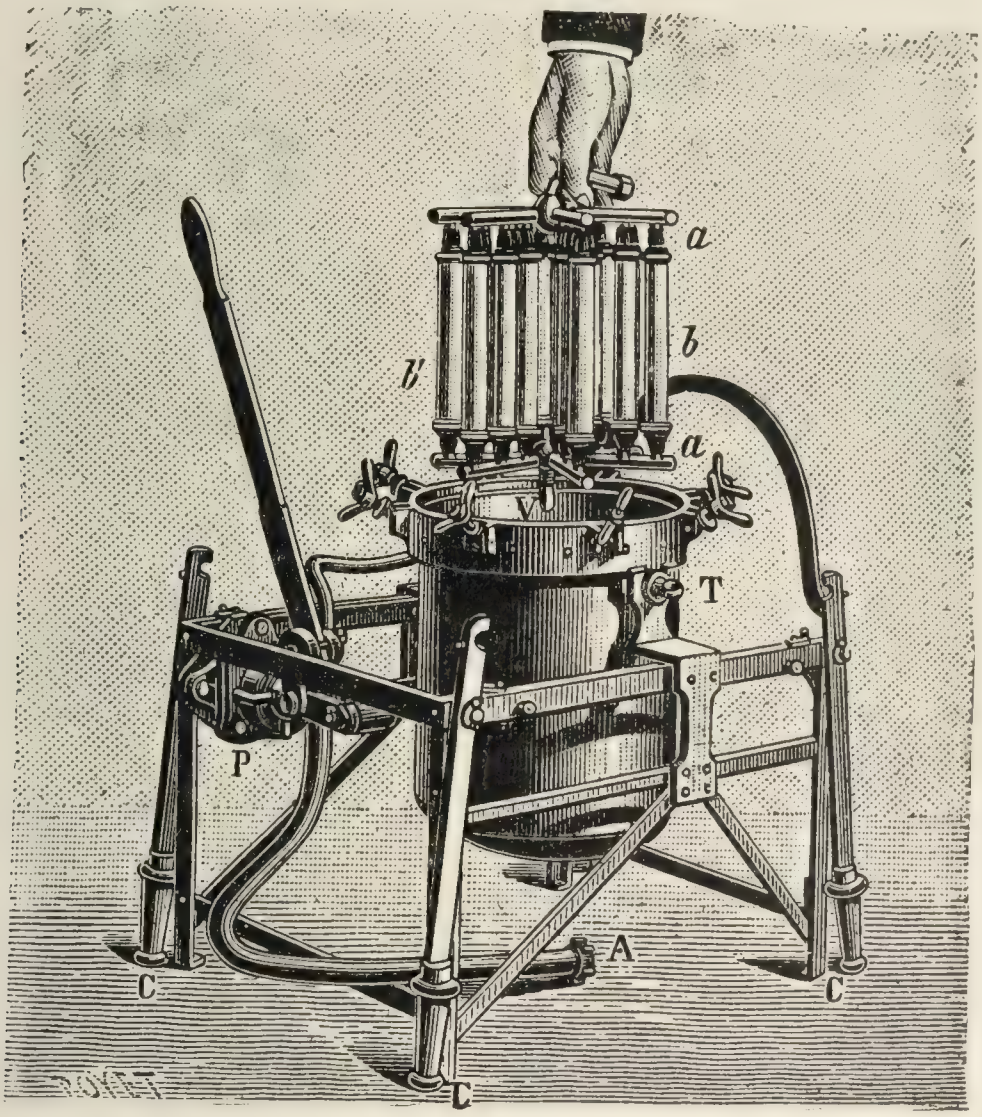


FIG. 46.—Battery of Pasteur-Chamberland Filters as Used in the French Army.

often be a matter of the greatest difficulty. During cold weather due care must be given these filters to prevent their injury by freezing.

It is obvious that to store filtered water in an unclean receptacle, or to mix it with unfiltered water, is to destroy the special advantage of filtration by the Berkefeld or Chamberland apparatus.

Purification by Chemical Means.—While the unhealthfulness of a water is probably rarely due to mineral matter held in suspension, the clarification of a turbid water will at times be desirable. Where filters are not available such waters may be cleared by sedimentation, the process being materially aided by the use of alum. In China, the removal of suspended matter is thus commonly effected; the natives stirring the water to be clarified with a small bamboo pierced with holes and containing this substance. In general, the proportion of 6 grains of alum to the gallon of water is sufficient. The method is most satisfactory when calcium carbonate is present in the water, and if this be absent the addition of a little

sodium carbonate prior to the use of the alum is advisable. The carbonates present in the water readily decompose the alum with the formation of a white gelatinous precipitate of aluminum hydrate; this, together with calcium sulphate, entangling suspended particles and carrying them down to the bottom. The reaction, where the carbonate of calcium is concerned, is as follows: $K_2 Al_2 (SO_4)_4 + 3 CaCO_3 + 3 H_2 O = 3 CaSO_4 + K_2 SO_4 + 3CO_2 + Al_2 (OH)_6$.

The time required for the sedimentation of water treated with alum is short, and the clear fluid which may soon be decanted off may be further purified by boiling or filtration.

The deposition of the earthy matter held in suspension mechanically removes, also, a varying proportion of organic matter and bacterial life. In general, the more turbid the water the greater the proportion of germs carried down during clarification. De Santi and Lejeune found that most of the bacterial life was removed by alum, and Babes went even so far as to state that a proportion of one to five thousand is sufficient to sterilize drinking-water. Teich, however, found that it was extremely difficult to remove all micro-organisms by this method, and states that alum appeared to have no directly germicidal properties—the typhoid bacillus not being destroyed by a strength of one to three thousand, while the vitality of even as low a resisting germ as the cholera vibrio was not affected during an exposure of twenty-four hours.

The long continued use of alum water is said to induce digestive disturbances, and its employment as a means of purification is quite inferior to modern methods of filtration. It has, however, a practical value for field use in the absence of suitable filtering apparatus.

Where necessity requires the use of an extremely hard water it is often advisable, even in the field, to institute measures for its correction, at least in limited quantity. Vegetables cooked in hard water turn yellow, and beans and peas shrivel and harden. Meat boiled in hard water becomes tough and indigestible; while the use of such water for washing purposes is wasteful of both soap and labor. The common cause of hardness of water is due to the presence of calcium carbonate and also of the sulphates of calcium and magnesia. In pure water, calcium carbonate is soluble only to a very slight extent, but in water which holds free carbon dioxide in solution, one pound of calcium carbonate can be dissolved in five hundred and sixty gallons of water by seven ounces of the gas. It is also soluble in water from an almost opposite cause—by driving off the carbon dioxide from the carbonate and reducing the latter to the oxide. In burning one pound of calcium carbonate, seven ounces in weight is lost by the expulsion of carbon dioxide, and the remainder, consisting of nine ounces of calcium oxide, is then entirely soluble in forty gallons of water. Clark's process for removing the hardness of water takes advantage of these facts. The water to be softened is mixed with water containing quick-lime in the above proportions, when the seven ounces of free carbonic acid gas, which held the first one pound of calcium carbonate in solution, combines with the nine ounces of quick-lime to form one pound of calcium carbonate; and this, together with the first one pound of calcium carbonate no longer soluble through the loss of the free carbon dioxide, is precipitated out. This process is simple and convenient, but is more advantageously carried

out on a large scale. In the precipitation of calcium carbonate a considerable proportion of suspended matter is also removed.

Hard waters may also, to a certain degree, be corrected by the addition of sodium carbonate. If beans are to be cooked in hard water a small pinch of soda to the liter of water is usually sufficient, but where the quantity of soda is very great the beans take on an alkaline taste and are reduced to a soupy consistency. Where the water is to be used for drinking, the quantity of soda to be added should be determined by chemical analysis. The sodium sulphate so formed is in no way harmful, while the resulting calcium carbonate is precipitated out.

Based on the three methods detailed above, Maignen has devised a powder, sold under the trade name of "anticalcaire," for the purification of water. This is composed of a mixture of lime, sodium carbonate and alum; the relative proportions being made to vary with the character of the water to be purified. Laveran, however, experimenting with this powder, was unable to effect the sterilization of water, even when the powder was used in the proportion of one to two thousand, although the number of bacteria was markedly reduced and clarification was excellent. It has not been shown that Maignen's powder can be employed any great length of time without inducing intestinal disorders.

A ready method of clarifying water, but available in certain regions only, consists in the addition of "prickly pear" or cactus leaves which have been previously cut up and bruised. The water is preferably allowed to clarify over night.

The use of permanganate of potash for the purification of water, by the oxidation of organic matter, has been advised by Schipiloff and others. No definite strength can be suggested, since the amount of permanganate of potash required necessarily varies with the quantity of organic matter to be oxidized. The usual procedure consists in adding small quantities of a strong solution of potassium permanganate to the water to be purified, stirring constantly during the operation. An excess of the reagent is indicated by a permanent pink tint, which should remain for at least half an hour before being discharged. The rosy color of the permanganate in excess can best be discharged by the addition of a weak solution of citric acid, or, in its absence, of tartaric acid. Sugar, after inversion by boiling with vinegar, may also be used, but its action is slow and considerable quantities are required. Experiments by the writer showed that 100 c.c. of a .05 per cent. solution of potassium permanganate was decolorized in ten minutes by 10 c.c. of a 1 per cent. solution of citric acid, and by 5 c.c. of the same solution in thirty-five minutes. Using the same strength of permanganate solution, 10 c.c. of a 1 per cent. solution of tartaric acid decolorized 100 c.c. of the permanganate solution in thirty-five minutes, and 5 c.c. in sixty-five minutes. Chicandard states that water may ordinarily be sterilized by the use of 5 to 10 cgm. of the potassium salt to the liter of water. Coreil, however, states that as much as 10 to 20 cgm. per liter does not sterilize, but merely reduces the number of micro-organisms. It is probable that these dissimilar results were due to a difference in the amount of organic matter present in the waters examined by these observers. Laveran found that, under ordinary circumstances, a strength of 0.5 gm. to 0.6 gm. of permanganate to the liter could be depended

upon to kill pathogenic bacteria if the exposure were continued for several hours.

One objection to the use of permanganate is that it often communicates a yellow tint to the water, arising from suspended finely divided peroxide of manganese. This is probably of no moment as far as health is concerned, but it is unsightly. Sometimes the addition of a little alum will carry down this suspended matter; boiling may be used, but often has no effect. Sometimes nothing removes it but filtration. Potassium permanganate readily removes the odor of hydrogen sulphide, and has a special value in destroying the peculiar offensive odor of impure water which has been kept in casks or barrels.

Permanganate of calcium has been suggested by Bordas and Girard for use in connection with the purification of water. On contact with organic matter this substance rapidly decomposes in the production of oxygen, oxide of manganese and lime; the presence of carbonic acid in the water favoring this decomposition through the affinity between lime and carbon dioxide. The excess of calcium permanganate remaining in the water is removed by filtration through coke and the black oxide of manganese.

Schumberg has recently described a method of sterilizing water, by the use of bromine, which appears to possess a special value for the military service. In this method a 20 per cent. solution of bromine is used, thirty drops being sufficient to sterilize a quart of water in five minutes. The bromine is then neutralized by ammonia in the production of ammonium bromide; thirty drops of a 9 per cent. solution of ammonia being sufficient to exactly neutralize. It is desirable that actual neutralization should be obtained, although a faint taste of bromine or ammonia is not seriously objectionable. In case the water is very hard or foul the bromine may be cautiously added until a faint yellow color is produced.

Watt has proposed the use of perchloride of iron for the sterilization of water, this salt being neutralized by calcium hydrate or sodium carbonate. This produces the hydroxide, which, on precipitating, carries down the micro-organisms in suspension. After sedimentation, the water is filtered. The water so obtained is undoubtedly very pure, but the method is open to the criticism of using a salt which is itself corrosive to metals and which, in common use, would not be free from the danger of accidents.

It is stated by Christmas that, as far as the cholera vibrio is concerned, water may be as surely sterilized by the addition of 0.6 gm. to 0.8 gm. of citric or tartaric acid, per liter, as by boiling. This proceeding is very simple and may be used with advantage during the prevalence of cholera infection.

CHAPTER V.

I.

THE RATION.

General Consideration of Food.—Food is that which, when taken in the body, builds up tissue, repairs waste or is consumed in the production of heat and energy. If food be in excess of the requirements of daily consumption it may be stored up, chiefly in the form of fat, for future use. The best nutritive substances are those which perform their function in the most thorough and complete manner; that is, with as little waste as possible and with the best physiological results. They should be digestible and palatable, and, when brought together in the diet, should furnish in proper amounts the different substances required by the system. The latter point, in determining the dietaries of soldiers, is of much importance. It may be assumed that, in general terms, nitrogen and carbon represent the materials required. No single article of the ration, however, yields these substances in the proportion desired. The soldier confined solely to a meat diet would be required to take into his system about four times as much nitrogen as would be necessary in order to get sufficient carbon; while a diet of bread alone would overload the organism with carbon before a sufficiency of nitrogen was attained. Foods, from their different chemical composition, are therefore used most advantageously to supplement each other.

Food-stuffs are usually classified, according to their proximate composition, as follows:

- I.—Organic
  - Nitrogenous, as proteids or albuminoids.
  - Non-nitrogenous
    - (*a*) Fats.
    - (*b*) Carbohydrates.
    - (*c*) Vegetable acids.
- II.—Inorganic
  - Mineral salts.
  - Water.
- III.—Food accessories, as tea, coffee and condiments.

The first two classes of food-stuffs are essential to life; the third class is important as favoring palatability and digestibility.

The true nutrients are protein, fats and carbohydrates; and these, within the organism, serve the following general purposes:

Protein forms tissue (as muscle, tendon, and fat) and serves as fuel	All yield energy in form of heat and muscular strength.
Fats form fatty tissue (not muscle) and serve as fuel	
Carbohydrates are transformed into fat and serve as fuel	

The protein and fats of body tissue are used like those of food. In being themselves burned to yield energy the nutrients protect each other from being consumed. An important use of the carbohydrates and fats is to protect protein from consumption. All foods contain water in considerable

but varying proportion; and many of them contain considerable material, as the bone of meat and the skins of potatoes, which cannot be employed for purposes of nutrition. In the adjusting of diet to the demands of the body, the important matter is to provide enough protein for the building and repair of tissue, and enough energy to keep it warm and do its work. Considering the body as a machine, there must be material to construct it and keep it in repair, and fuel to supply heat and power. If there is not food enough, or the nutrients are not in the right proportions, the body will be weak in its structure and inefficient in its work. So, likewise, if there is too much, damage to health will ultimately result. The latter contingency is scarcely to be apprehended in the military service.

While fats and carbohydrates may within certain limits replace each other in the dietary, neither can take the place of protein. A sufficient supply of the latter is essential, and if the income of nitrogen, which is present in food only in protein, be not equivalent to the outgo—the amount of the latter varying with the individual and the work to be performed —a condition of inanition, resulting in death if the deprivation of protein be sufficiently continued, is certain to ensue; although for a time the muscles will carry on work at the expense of their own albuminous constituents. On the other hand a large excess of nitrogenous material in the diet is undesirable; and it is of advantage if the amount of protein taken in as food can be reduced, through the ingestion of a proper amount of fats and carbohydrates, to about the point required for constructive and reparative purposes alone. Protein is a source of energy, as well as of repair, in the body; but it is undesirable to employ it for the former purpose, since its oxidation leaves behind a large amount of nitrogenous matter which must be passed out of the organism as an excrementitious body. No constant figure can be given as to the amount of protein which should be taken as food by each individual, but physiologists are agreed that 150 gm. of protein may be regarded as sufficient for the needs of men at such labor as may be required of the soldier. The amount of nitrogen is found by dividing the amount of protein by the factor 6.25.

Fats find their use as sources of energy and heat to the body. Fat has a place in all dietaries, its relative proportion in the food consumed being much increased in cold climates. When hard work is to be performed fat is also instinctively taken, since it possesses a high calorific and potential value. The amount of fats consumed by inhabitants of the United States is considerably greater than that used by corresponding classes in other countries of the temperate zone, and our military ration is also far superior to those of foreign armies in respect to its fatty constituents.

The consumption of carbohydrates not only spares proteid food but also fat, being utilized in the production of heat and energy. As compared with fats, carbohydrates are a less concentrated fuel; but they may be transformed into the latter in the body and thus become a reserve source of energy and warmth. The greater proportion of carbohydrates are, however, directly consumed within the body; and excess of carbohydrates, owing to the bulk of the food taken, appears to derange digestion.

The inorganic constituents of food, especially water and sodium chloride, play an important part in the dietary. Death ultimately follows deprivation of the two constituents named.

An important point with respect to the nutritive value of foods is their digestibility, since it is evident that only such portion as can be reduced to a condition in which it may be absorbed will be of value to the economy. Much experimental work has been done on this point, and the results obtained may be briefly summarized as follows:

1. The protein of ordinary meats and fish is very readily and completely digested. The protein of vegetable foods is much less completely digested than that of animal foods. Of that of potatoes, whole wheat and rye flour, one-fourth or even one-third may escape digestion and thus be useless for nourishment. Roughly speaking, one-sixth or one-seventh of the protein of wheat flour, corn meal, beans and peas may be assumed to be undigested when cooked and eaten in the usual way. With inexperienced cooks, and especially in the field, a still greater proportion may be unavailable for nutritive purposes through lack of proper preparation.

2. Much of the fats of animal food may at times fail of digestion. This is presumably true of vegetable fats, but the quantities are in general so small that the determinations of the proportions digested are not very accurate. The experiments thus far made imply that perhaps five per cent. of the fat of meats, butter and lard will escape digestion as they are ordinarily eaten.

3. The carbohydrates, which make up a large part of vegetable food, are in general very completely digestible. The crude fiber or cellulose is an exception; but the quantities of this in the materials used for the food of man are too small to be of importance. Sugar is believed to be completely digested. The carbohydrates of animal foods are very small in amount.

4. The animal foods have, in general, the advantage of the vegetable foods in digestibility, in that they contain more protein and that their protein is more digestible.

5. The quantity digested appears to be less affected by flavor, flavoring materials and food adjuncts, and to differ less with different persons, than is commonly supposed.

Relation of Food to the Work of the Soldier.—For the military service a knowledge of the potential energy latent in food is desirable in calculating the amount and character of the nutritious substances capable of yielding sufficient energy for the performance of a definite amount of external muscular work; since force manifested in the living body must be the correlative expression of force previously latent in the food eaten or the tissue formed. This potential energy latent in nutritive material can be measured like heat or mechanical power; and work to be done may be calculated in foot-tons, which can also be readily expressed in terms of food or foods. In practice, however, such a calculation is not exact and is only of relative value, since the mere expression of potential energy cannot exactly fix a dietetic value which may be dependent on conditions of the body unknown to us. Experiments made by Helmholtz seem to show that this external work should be one-sixth to one-fifth of the mechanical force latent in the digestive food, but conditions must be very favorable to obtain this proportion, and in practice probably only one-sixth to one-seventh may be expected. It is obvious that, given a definite amount of nutritive fuel capable of conversion into heat or energy, the re-

quirements of the system would be greater, in respect to the former, in a cold climate than in a warmer one, and the energy available from the combustion of this food would be proportionately diminished by the greater expenditure for heat. Hence a diet sufficient for the accomplishment of a certain number of foot-tons of labor in the United States should properly be increased for troops performing the same amount of labor in Alaska or along the Canadian border—or could be safely diminished for tropical service.

The unit commonly used for the measurement of the fuel value of food is the large calorie, this being the amount of heat which would raise the temperature of 1 kilogram of water 1° C., or 1 pound of water 4° F. The same word "calorie" is used also to designate the heat required to raise the temperature of 1 gm. of water 1° C. The large calorie is usually spelled with a capital "C," and represents 1,000 of the small calories. In this work the large Calorie only will be employed. The English heat unit is sometimes used in calculating diets; this being the amount of heat required to raise the temperature of 1 pound of water 1° F., and representing the dynamic equivalent of the power required to raise 772 pounds to the height of 1 foot. Usually, in estimating the potential value of dietaries, the unit of mechanical energy employed is the foot-ton, 2,240 pounds raised through 1 foot, of which the English heat unit obviously equals about one-third. One Calorie thus corresponds to very nearly 1.53 foot-tons. Taking ordinary food materials as they come, the following general estimate has been made for the average fuel value of 1 gm. of each of the proximate of nutrient principles:

	Calories of heat.	Foot-tons of energy.
In 1 gm. of protein there are latent.....	4.1	6.3
In 1 gm. of fats there are latent.....	9.3	14.2
In 1 gm. of carbohydrates there are latent.....	4.1	6.3

These figures mean that when a gram of fat, be it the fat of food or body fat, is consumed in the body, it will, if its potential energy be transformed into heat, yield enough of the latter to warm 9.3 kilograms of water 1° C., or 4 pounds of water 1° F.; or, if it be transformed into mechanical energy, such as the muscles use to do their work, it will furnish as much as would raise 1 ton $14\frac{1}{5}$ feet, or $14\frac{1}{5}$ tons 1 foot. A gram of protein or carbohydrates yields a little less than half as much energy as a gram of fat.

Using the above figures and knowing the percentage composition of the articles of the rations—as given later—the amounts and proportions of the food theoretically required to furnish the energy for any given amount of external muscular work can readily be calculated. For practical application, however, it is necessary to know about the amount of external muscular work performed by the soldier under various conditions—the average limit of human endurance for adult males being generally put at about five hundred foot-tons, during the twenty-four hours, in temperate climates. The expenditure of this great amount of energy, however, could not be continued any great length of time. Assuming the principal work of the soldier to consist in marching, walking at three miles per hour, as stated elsewhere, is equivalent to raising one-twentieth part of the weight of the

body through the distance walked. Using this calculation, and assuming the soldier with his clothing to weigh one hundred and sixty pounds, the following figures are obtained for the energy required in marching on level ground:

	Work done in tons lifted one foot.
Marching one mile	18.86
" two miles	37.72
" ten "	188.60
" twenty "	377.20
" one mile and carrying sixty pounds	25.93
" two miles " " " "	51.86
" ten " " " " "	259.93
" twenty " " " " "	518.60

In practice, however, the ground over which the soldier marches cannot be regarded as level, while the weight of the accoutrements is rarely adjusted correctly. Military drill without arms is estimated by Hickman as being one-third more fatiguing than ordinary walking, and four hours' drill for recruits as being equivalent to the daily work of the ordinary agricultural laborer. The duties of the soldier outside of marching are very various and obviously cannot all be, in practice, reduced to exact figures in foot-tons. In general, however, the daily output of energy may be estimated with sufficient accuracy by comparing the muscular exhaustion resulting from any task with the labor expended in marching, as calculated above. Taking all things into consideration, three hundred and fifty foot-tons may be accepted as a fair estimate of the average day's labor which may be performed by the soldier. In considering the amount of food required, however, a certain excess over the quantity sufficient to furnish energy for the accomplishment of these three hundred and fifty foot-tons of work should be allowed, since there should be a certain amount of reserve force upon which the soldier may draw during unusual trial and hardship. Exactly how much food is considered by physiologists to be required by men performing hard manual labor, equal to that demanded of the soldier, and what its proximate character should be, is considered subsequently.

Requirements of the Soldier's Dietary and Ration.—The conditions governing a perfect dietary may be considered to consist in:

1. The determination of the real nutritive wants of the body under different labor and climate.

2. A proper selection of food as regards quality, nutritive power, appetizing property and digestibility.

3. The association of foods in such wise as not to offend the appetite or burden the digestive powers.

4. A right treatment of nutritive substances by cooking, so as to render them most useful to the system.

5. A just distribution of the daily diet in appropriate meals.

These conditions especially apply to the soldier, who, considered as a machine, must be kept in good repair and supplied with sufficient motive power. A deficiency in nutritive material means diminished vital resistance and impaired strength, which for a time incapacitates the individual and renders him unable to fulfil his duties. It is most important that work done by the soldier should be evolved from the food taken and not

from the tissues of the body, since sickness will otherwise ultimately result. Only in great emergency, and then but for brief periods, should the tissues be called upon for the production of energy.

As to the special qualities of the military ration, in addition to possessing adequate nutritive value, its components should be sufficient in number to afford a reasonable variety to the food consumed by the soldier. They should also be easy of preparation. Since troops must often be fed at considerable distances from the point of supply, it is evident that the articles included in the ration must be readily transportable and easily preserved. Bulky articles offer obvious disadvantages, and hence the ration

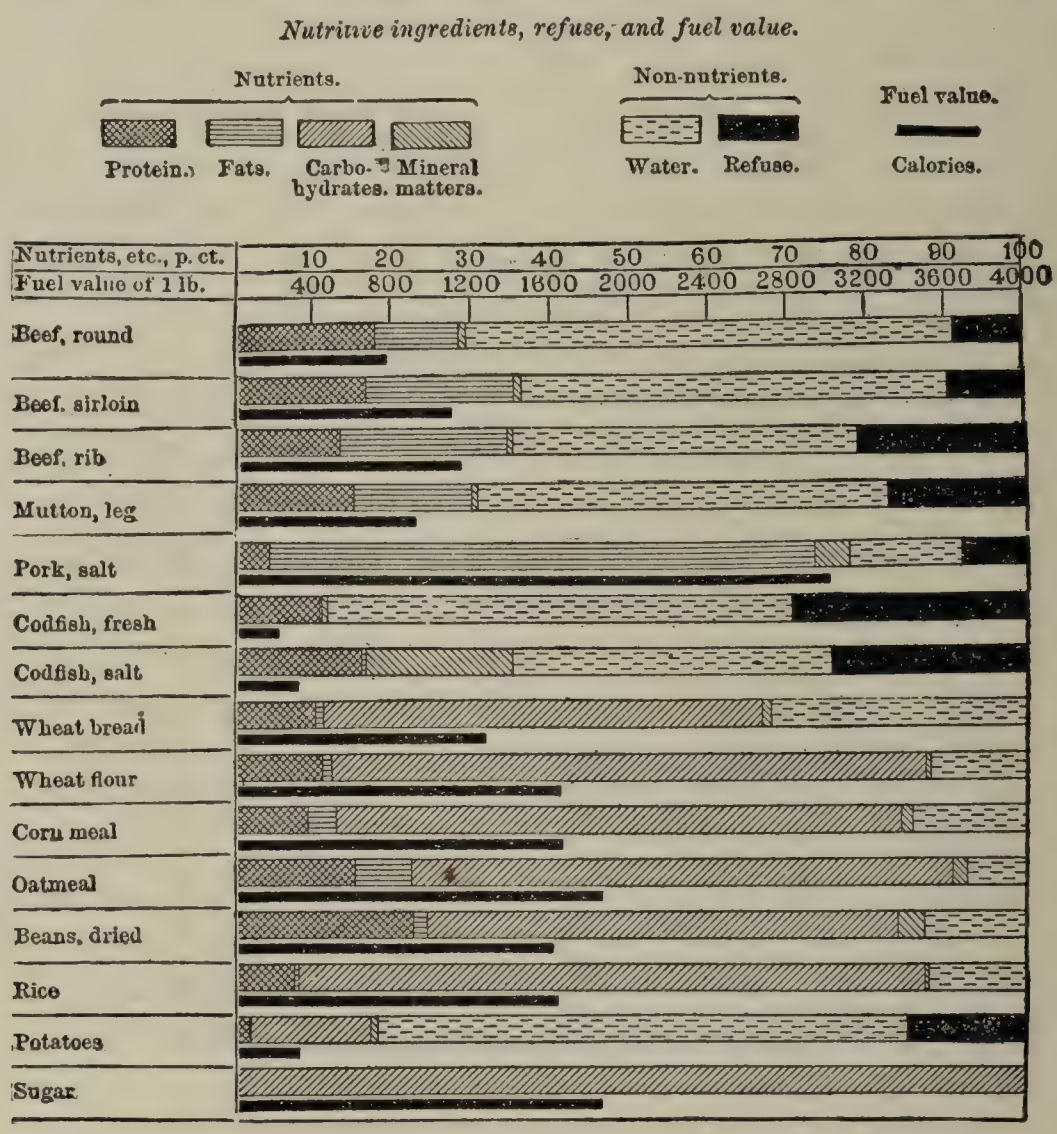


FIG. 47.—Proportionate Composition of the Chief Food Materials Entering into the United States Army Ration. (After Atwater.)

must largely be dry; but, on the other hand, a certain amount of fresh food is necessary to health. Coupled with these requirements, the nutritive substances must be so inexpensive as to refute any charges of extravagance, and must be articles abundantly produced and commonly consumed within the limits of the state. From the circumstances of the case, the character of the food available for use in the field in time of war is necessarily somewhat different from that issued in garrison in time of peace.

Quantity of Ration.—In the United States army the nutrition of the soldier depends on the allowance of food—or ration—provided at government expense; on the additional food purchased from the funds accruing from the post exchange and the disposal of salable property; the food purchased by the soldier from his private resources and eaten by him at the post exchange or other resort; and the food furnished by post gardens and by hunting and fishing parties. Of these, the first is by far the most im-

portant, the other sources of supply being merely supplementary to it and by no means constant. Particularly is this the case in the field, where a liberal supply of nutritive substances is most desirable and yet where the means of supplementing the ration by gardens, exchange dividends or personal outlay is naturally wanting. The ration by itself, therefore, should supply to the soldier a quantity and variety of articles of food which, under proper manipulation, should yield dietaries of moderate nutritive value for the routine duties of garrison life or should be capable of furnishing sufficient energy and of repairing body waste under any of the conditions under which troops may be forced to campaign. Nothing should be left, with regard to food, to chance or opportunity. Insufficient nourishment directly disposes to disease by lowering the powers of vital resistance; and from the economic view a weak, under-fed soldier is no soldier, costing the nation to support him more than his services are worth. Particularly in the field must the allowance of food be liberal. The average appetite of the command is the theoretical measure of this allowance, but in practice this should be exceeded to afford a margin or surplus for contingencies. Overfeeding may have its dangers, but these are scarcely to be dreaded in the military service. Armies have been disarmed by a deficient dietary, but never by over-feeding consequent on the establishment of a liberal ration. Bearing these facts in mind, it is important to gain an understanding as to the sufficiency and composition of the ration supplied the soldier, both with regard to its individual components and as a whole. The following table, compiled from data elaborated by Atwater and Bryant, shows the quantities, chemical composition and nutrient values of the various articles of the ration as at present issued in our service:

Articles of Ration.	Quantities per ration, ounces.	Amounts Present in Ration (Grams).				Fuel value per ration, Calories.
		Protein.	Nitrogen.	Fats.	Carbohydrates.	
Fresh beef (fore and hind quarters)....	20	83.35	13.3	89.5	....	1,180
Or Fresh mutton.....	20	92.4	14.7	125.8	....	1,440
Pork.....	12	55.08	8.8	225.08	...	2,187
Bacon.....	12	31.28	4.99	210.12	....	2,085
Salt beef.....	22	88.6	14.16	142.3	....	1,534
Dried fish (cod).....	14	63.52	10.16	1.59	....	276
Fresh fish (cod, whole).....	18	40.8	6.5	1.02	....	155
Pickled fish (mackerel).....	18	70.90	11.18	108.14	....	1,029
Canned fish (salmon).....	16	88.42	14.14	34.00	....	680
Flour.....	18	55.08	7.9	5.6	380.46	1,850
Or Soft bread.....	18	48.45	6.9	6.12	269.28	1,355
Hard bread.....	16	65.7	10.44	5.9	330.5	1,712
Cornmeal.....	20	50.4	7.99	12.4	425.8	1,986
Beans.....	2⅖	15.16	2.42	1.22	40.18	240
Or Rice.....	1⅗	3.5	.56	.18	35.55	163
Peas.....	2⅖	16.38	2.62	.75	41.8	246
Hominy.....	1⅗	3.69	.59	.27	35.5	172
Potatoes.....	16	9.5	1.52	.45	81.7	380
Or Potatoes 80 per cent., and onions 20 per cent.....	16	8.6	1.4	.72	73.09	340
Potatoes 70 per cent., and canned tomatoes 30 per cent.....	16	8.16	1.30	.58	62.59	297
Dried fruits (average of varieties issued)	2	1.18	.19	1.02	33.8	147

Articles of Ration.	Quantities per ration, ounces.	Amounts Present in Ration (Grams).				Fuel value per ration, Calories.
		Protein.	Nitrogen.	Fats.	Carbo-hydrates.	
Sugar	$2\frac{2}{5}$	....	....	....	64.6	264
Or Molasses	$\frac{16}{25}$ gill.	....	....	....	41.25	198
Cane syrup	$\frac{16}{25}$ "	....	....	....	41.36	198
Coffee, green	$1\frac{3}{5}$					
Or Coffee, roasted	$1\frac{7}{25}$					
Tea, green or black	$\frac{8}{25}$					
Vinegar	$\frac{8}{25}$ gill.					
Salt	$\frac{16}{25}$					
Pepper	$\frac{1}{25}$					
Baking powder	$\frac{16}{25}$					
Soap	$\frac{16}{25}$					
Candles	$\frac{6}{25}$					

From the above table it is at once apparent that the ordinary variation of the articles composing the food of the soldier, as contemplated in the establishment of alternative components of the ration, does not furnish dietaries of the same proximate composition or nutritive value. Using the figures just given, the proximate composition and nutrient value of the maximum quantity of food material which may be drawn as a daily allowance by the United States soldier are seen to be as follows:

Articles.	Quantity in ounces.	Fats, grams.	Carbo-hydrates, grams.	Protein, grams.	Nitrogen, grams.	Fuel value, Calories.
Fresh beef	20	89.50	.....	83.35	13.30	1,180
Flour	18	5.60	380.46	55.08	7.90	1,850
Beans	2.4	1.22	40.18	15.16	2.42	240
Potatoes	16	.45	81.70	9.30	1.52	380
Dried fruit	2	1.02	33.80	1.18	.19	147
Sugar	2.4	....	64.60	....	....	264
Total	60.8	97.79	600.74	164.27	25.33	4,061

Total carbon, 427.03 gm.; nitrogen to carbon, 1:17.

In the following table are included those articles of food which, taken together, may be considered to constitute the ordinary ration for troops in the field or during active campaign. No fresh vegetables are considered in this dietary.

Articles.	Quantity in ounces.	Fats, grams.	Carbo-hydrates, grams.	Protein, grams.	Nitrogen, grams.	Fuel value, Calories.
Bacon	12	210.12	....	31.28	4.99	2,085
Hard bread	16	5.90	330.50	65.70	10.44	1,712
Beans	2.4	1.22	40.18	15.16	2.42	240
Dried fruit	2	1.02	33.80	1.18	.27	147
Sugar	2.4	....	64.60	....	....	264
Total	34.8	218.26	489.08	113.32	18.12	4,448

Total carbon, 432.78 gm.; nitrogen to carbon, 1:23.8.

A selection of food-stuffs contained in the ration commonly employed by troops in garrison is given in the following table, but to the figures yielded by them must in practice be added those for whatever additional foods might be purchased from the savings in flour, beans and other articles, possible with this dietary:

Articles.	Quantity in ounces.	Fats, grams.	Carbohydrates, grams.	Protein, grams.	Nitrogen, grams.	Fuel value, Calories.
Fresh beef	20	89.50	....	83.35	13.30	1,180
Soft bread	18	6.12	269.28	48.45	6.90	1,355
Potatoes and onions	16	.72	73.09	8.60	1.40	340
Dried fruit	2	1.02	33.80	1.18	.19	147
Sugar	2.4	....	64.60	....	....	264
Total	58.4	97.36	440.77	141.58	21.79	3,296

Total carbon, 344.57 gm.; nitrogen to carbon, 1:16.3.

In the following dietary a combination is given in which a full daily allowance from each component of the ration is included. This dietary represents the least amount of nutritive material which can be drawn by the United States soldier; but to it, as in the previous instance, should be added the additional articles of food which would be purchased from the savings on flour, coffee and vinegar, thus considerably increasing its nutritive value.

Articles.	Quantity in ounces.	Fats, grams.	Carbohydrates, grams.	Protein, grams.	Nitrogen, grams.	Fuel value, Calories.
Fresh fish (cod, whole)	18	1.02	....	40.80	6.50	155
Soft bread	18	6.12	269.28	48.45	6.90	1,355
Rice	1.6	.18	35.55	3.50	.36	163
Potatoes and tomatoes	16	.54	65.80	8.17	1.36	297
Dried fruits	2	1.02	33.80	1.18	.19	147
Sugar	2.4	...	64.60	....	....	264
Total	56	8.88	409.03	102.10	15.51	2,321

Total carbon, 241.84 gm.; nitrogen to carbon, 1:16.7.

In considering the sufficiency of the ration the maximum allowance which can be drawn, as given in the first dictary, will alone be of importance; and this should be compared with accepted dietary standards as determined for the corresponding laboring classes in civil life. These are variously given by Atwater, for different countries, as follows:

	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.
Active muscular labor. Atwater (American standard)	150	150	500	4,060
Men at hard work. Voit (German standard)	145.12	99.77	448.96	3,370
Active laborers. Playfair (English standard)	154.19	72.56	566.87	3,630

On comparing the American standard proposed by Atwater with the combination of components of the ration given in the first dietary, noted above, it is seen that the fuel value almost exactly corresponds in both. The fats are somewhat deficient in the ration dietary, but the carbohydrates and protein are in excess. Ordinarily in our service, however, in each ten days there are seven issues of fresh meat and three of bacon and pork. This makes a considerable change in the character of the dietary; and, substituting the average figures of the beef and bacon issues for those of beef alone, the nutrient value and composition of the maximum food allowance for the soldier is seen to be as follows:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.
152.79	134.97	600.74	4,332

This dietary has a force-value somewhat higher than the standard mentioned above, and the carbohydrates are also in excess. The deficiency in fats is but slight, while the amount of protein is seen to be almost exactly the theoretical normal for this country. As a whole, and in each of its proximate principles, the United States army ration is much superior in nutritive value to the allowance of food which is regarded by foreign authorities as quite sufficient for the needs of men at hard labor in England and Germany.

As shown by the above figures, the food-value of the ration is in considerable excess of the nutritive material found by Atwater to be actually eaten in the training diets of the Yale and Harvard University crews during the hard labor of the racing season of 1898. These diets gave the following average:

Protein, grams.	Fat, grams.	Carbohydrates, grams.	Fuel value, Calories.
155	177	440	4,085

From these and numerous similar results it may be fairly accepted that according to American standards of diet, which are much higher than those obtaining abroad, the United States army ration is somewhat more than sufficient to meet all the demands of active muscular labor in a temperate climate. That this is, indeed, the case is shown not only by comparison of the ration with the above standards, but also by long practical and satisfactory experience with its use in garrison and in the field, and the fact that recruits subsisting upon it gain largely in weight and attain a high degree of physical development. As shown later, the standard ration is in excess of the physiological needs of the soldier on tropical service, but, on the other hand, it is undoubtedly insufficient for service in the far north. Atwater's more recent investigations place the American standard for exhausting labor at forty-five hundred Calories. Hence for a continuous winter campaign of arduous nature the ration could with advantage be slightly supplemented by special issues, varying in quantity according to circumstances. In such instances the additions should be chiefly in the line of an increase in protein and fats, especially the latter, as expressed in the beans and bacon components.

In connection with the question of the sufficiency of our ration the following analyses of the several rations of the German army, as given by Atwater, are instructive:

German army.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nutritive ratio (protein to energy).
Ration, peace footing	113.37	40.81	480.71	2,800	5.0
Ordinary ration, war footing...	136.05	58.95	489.78	3,095	4.6
Extraordinary ration, war footing	190.47	45.35	676.71	3,985	4.1

From this it will be seen that even the maximum German ration is quite inferior to our food allowance except in the matter of protein, and in this respect the German ration is undoubtedly unduly high.

It is of interest to note, also, the limited quantities of food under which troops can perform efficient military service. According to Dunlop, the food value of the rations issued to British troops lately besieged in Ladysmith, South Africa, yielded but 73.4 gm. of protein, 69.7 gm. of fats and 141.6 gm. of carbohydrates. The fuel-value of this ration was but 1,527 Calories. This diet is extremely small, being even less than prison or poorhouse diets for persons at rest, yet it furnished a sufficient supply of energy for a stout and successful resistance, extending over a considerable period. Of course the performance of hard marching with such a dietary would have been quite impossible.

In this connection it may be remarked that while some men eat more than others at all periods of their lives, it is an almost universal rule that the young and growing eat and require more food than do those whose development is complete. The same applies also to such as have been long under-fed before their enlistment. The gluttony of men recently enlisted is a constant source of surprise to old soldiers, and it is well to give such immature recruits the desired sense of fullness by the liberal supply of bulky vegetable foods. For such men to eat of concentrated foods to satiety is to invite sickness.

Quality of Ration.—While the quantity of food supplied to the soldier is defined by regulations, its quality is largely dependent on the efficiency of the Subsistence Department and its preparation for use lies with the consumers. It is obvious that quality is a factor of the greatest importance, since an inferior character of supplies means that the soldier does not receive subsistence of the nutritive value to which he is entitled. The various methods for the determination of quality in the articles of the ration are detailed in the special mention given them subsequently, and it will here be only remarked that the issue of stores as far as possible in the order in which they are received, as required by existing rules, will often result in the sale of articles which have undergone certain deterioration; fresh articles lately received in stock perhaps remaining in store to their detriment until their time for issue arrives. This plan undoubtedly results in a saving to the Government, but is not always to the best interests of the soldier. To limit the bad effects of this rule it is desirable that the supply of perishable articles, as kept on hand by the commissary, should be sufficient for a period of not more than one month.

Variety in Ration.—Variety, in food, is craved by all. However good a single article may be in itself, its continued and exclusive use for any length of time is sure to inspire distaste and consequently to impair its nutritive value. Nutrition depends on assimilation, and assimilation on the tone of the digestive tract, manifesting itself in taste and relish. Malnutrition arises from sameness of diet almost as surely as from deficient quantity, and the character of the organic tissues requires that their reparative material be gathered from many sources; the distaste and loss of appetite which follow the use of an unvaried dietary, however well arranged it may be as to its carbonaceous and azotized proportions, shows that it does not fulfill all the requirements of the system. The company officer should therefore use every effort constantly to vary the diet of his men, bearing in mind that by this means he secures the proper nutritive elements, in due proportion, in the surest and most economical manner.

The army ration is uniform throughout the country regardless of locality, climate or duty. Manifestly it can be exactly suitable only within very narrow conditions, if indeed perfectly to any. Bearing in mind that in tropical countries carbohydrates form the staple, while a mixed dietary is used in temperate climates, and fuel foods, or fats, are required under low temperatures, the diet of troops should be suitably modified in these respects according to their geographical distribution. It is obvious that special regulations for soldiers' fare cannot be promulgated to suit each locality and circumstance; and, with intelligent supervision on the part of officers, these are quite unnecessary. The alternative portions of the ration give it a wide range, which may be further increased by the exchange or sale of surplus parts and the purchase of other foods with the accruing funds; and the proper selection of these should be the constant study of the company officer. In addition to those of climate, the physiological requirements of the system, dependent on duty or season, should also be given consideration. In the field, variety in food is necessarily restricted as compared with garrison life—depending chiefly upon difficulty of supply, but also to some extent on the inefficiency of cooking utensils. The nearer the camp to a base of supply, or the more permanent it is, the more easily will the food be approximated to what is used in garrison.

Since a certain degree of sameness necessarily attaches to the most liberal government issue of food, any method which enlarges the scope of its nutritive qualities is valuable. Experience shows that variety of cooking answers many of the purposes of variety of diet, and the necessity for a good cook in the company kitchen is obvious. Simplicity in preparing food by no means militates against a certain degree of variety; and it may be expected that a cook who provides but one dish for a meal will prove expensive and unsatisfactory. A temporary change of cooks, from time to time, is often of benefit, since it brings into use varied methods of preparation; and constant supervision of the bills of fare, on the part of company officers, will tend to neutralize the tendencies of the kitchen to fall into routinism.

This question of variety in cooking, important as it is now conceded to be, was long completely disregarded in most armies, our own being somewhat better off in this respect. Until as late as 1886, variety in cooking was not prescribed in the French army; and, until 1850, soup made of

beef, bread and vegetables was the only food served to French soldiers at each of their two daily meals. This monotony of preparation was said to have done much to prevent a proper utilization of the ration. As late as 1857, testimony before the committee investigating into the condition of the British army showed that at that time a company was provided with two boilers, in one of which the men boiled their meat and in the other their potatoes. A soldier ate this diet from the date of his enlistment to his discharge; living on boiled meat, if he completed his service, for twenty-one years. Although the meat ration was scarcely adequate, a large portion was unused, as the men became sickened at the monotony in its preparation. There was no means of cooking the ration except by boiling.

Before leaving this subject it may here be emphasized that an abundance of properly varied, well-cooked food does much to promote contentment among troops. The palatability of his food is no less important to the soldier than to others, and attention bestowed on the company mess has no small influence in preventing dissatisfaction and desertions.

Wastage of Ration.—When proper economy in its administration is secured, the quantity of the authorized ration is sufficient. Through indifference on the part of the company commander, and with ignorance or lack of judgment on the part of the cook, the wastage of the ration may be so great as to bring its sufficiency into question. With raw soldiers, inexperienced officers and untrained cooks, as found in the volunteer forces, the wastage of the ration is often serious in this respect. A certain amount of loss is unavoidable—such as is due to the rotting of vegetables, their paring for the table or the presence of bone in meat—but outside of this, where there are efficient cooks, the kitchen waste should contain practically nothing of any food value to the soldier. Not only should every effort be made to prevent unnecessary loss in cooking, and to utilize all residues, but care should be had in the mess hall, while allowing sufficient food, to take all precautions against issuing portions larger than will presumably be utilized. Small portions, repeated if desired, should be the rule. The small amount of refuse left on an individual plate may appear trifling, but if this uneaten excess be left throughout a considerable part of the organization, it may have a food value equal to that of a number of full rations. Great care should be taken to preserve all grease and drippings. Such can be largely used in the preparation of food and gravies, and any excess is ordinarily salable. In one regiment in the British service it was found that the grease thrown out by the kitchens had an annual money value of nearly a thousand dollars. Bones, too, after being well boiled in the making of soup, have a commercial value. Woodruff estimated that, for a regimental post in Montana, the financial loss per year from bones thrown away amounted to a thousand dollars. The other refuse should have a value as fertilizer or for the feeding of stock, but in practice there is usually no market for it. As mentioned elsewhere, in some companies this refuse is fed to hogs, but such a practice is to be discouraged for sanitary reasons.

In a post having a strength of four hundred and forty men, during a period of ten days, Woodruff found the wastage in the more important articles of the food to be as follows:

Article.	Per cent. of waste.	Remarks.
Bacon	1.40	
Pork	8.00	Only nine pounds were reported, but this was increased to thirty-one pounds to include bones, etc.
Bread	3.30	Crusts and small unavoidable wastes.
Beef	22.50	Nineteen and three-quarters bone, two and three-quarters fat and other wastes.
Potatoes	27.09	Parings and defective ones.
Onions	21.04	
Prunes	33.00	Stones and other wastes.
Cabbage	45.00	
Ham	12.00	Estimated.

A wasteful cook, no matter what his other virtues, is always undesirable. In the general mess at Jefferson Barracks the civilian head-cook, paid by the mess at the rate of $1,000 per year, was shown to save the mess twice his salary through his superior economy; while at the hospital of the Soldiers' Home it was recently found that the chief cook effected a saving, over his predecessor, amounting to nearly $150 monthly. In both instances the men lived better than under a more wasteful administration.

Savings from Ration.—While no savings are permitted on fresh meat, fresh vegetables or dried fruit, with due economy some other portions of the ration will be saved and sold. The quantities naturally vary with different conditions—of which efficient management is most important. Climate and the nature of the service also have considerable influence in this respect. Ordinarily the cheaper articles will be drawn for use, and those of higher cost saved and their money value turned into the company fund. In many instances the local market rates are higher than the prices at which articles of the ration are sold by the Government. In such cases the company commander will draw his full allowance and dispose of any surplus to best advantage outside the camp or garrison. Most of the savings are made on flour and bacon, with smaller amounts on the other articles of the ration. The allowance of sugar is always required for use; generally some of the coffee can be saved, tea rarely. The condiment allowance is generally in excess. Food purchased from savings must not be regarded as in any way adding to the food allowance of the soldier, but as merely replacing other nutritive substances to the benefit of which he would otherwise be entitled. It may sometimes happen that certain articles are cheaper in the local markets than as supplied by the commissary; but ordinarily it is not true economy, quality being considered, to purchase outside food of the kinds which may be bought from the Government. In the field, especially during campaign, but little if any savings can be made from the ration; certainly none are supposed to be made. If they are made, it is questionable whether the commissary will have the purchasable articles on hand, since great difficulty is often experienced in keeping even the articles of regular issue available for troops. In general, the savings from the ration in garrison, under proper administration, will so supplement the diet as to supply abundantly all the actual needs of the command, though naturally falling short of luxury.

In the field no back rations are issued, and a command must draw its allowance when due or go without. Generally deprived of markets as

well as outside sources of revenue, marching soldiers fare worse for food than those in garrison and at the same time their nutritive requirements are greater.

Additions to Ration.—In garrison, the additions to the food furnished by the Government for the subsistence of the soldier will usually be considerable, and hence the articles and allowances of the legal ration by no means show what is actually consumed. Money is received in varying amounts from outside sources, independent of the savings on the ration proper, and this is almost wholly used for the purchase of such extra articles of diet as may be desired. Woodruff found that in a garrison of four hundred and forty men, during a period of three months, the average daily receipts and expenditures per man were as follows:

From ration	2.72 cents.
From post exchange	2.58 "
From other sources	.34 "
Total receipts	5.64 "
Expenditures for extra food	4.11 "

These figures, not including the savings from the ration itself, gave an increase to the soldier amounting to about one-fifth the value of the authorized ration. The savings from the ration are wisely not permitted to be used other than for the benefit of the soldiers' fare, and practically most of the money accruing from outside sources is devoted to the same purpose. Funds of this character should not be allowed to accumulate to large amounts and lie idle, since the soldier is entitled to an early share in the savings or exchange dividends which he has helped to create. On the other hand, a small reserve should be gradually acquired; so that when troops take the field and are reduced to subsistence on the bare ration, there should be a sufficient fund to permit the purchase of a fair amount of fresh food when it can be obtained. The limits of the company fund should be prescribed in orders, a reserve of $2 per man being sufficient. This sum would permit the daily expenditure of 2.2 cents per capita, outside the savings from the ration, for a period of three months. Troops will rarely be in the field, and without exchange dividends, for a longer period than this except during actual warfare. The latter contingency is so infrequently realized, and its probable duration is so completely beyond the powers of human calculation, that any effort to accumulate a large fund better to meet such conditions would not be justified. As to the expenditure of the company fund, the mere purchase of articles of food is a simple matter. To do so judiciously and to the best advantage should be the constant study of the line officer, and prove a subject about which he will learn to the last day of his service. To this end the nutritive and economic values of foods, the habits and tastes of the men and the skill of the cook in various methods of preparation will all receive due consideration. In general, variety will be sought and price and liability to deterioration will be fully considered.

Cooking of Ration.—Each soldier is supposed to be capable of cooking his own ration in a manner consistent with the preservation of health. To assist in obtaining this object an excellent cook-book is issued, but, as

a matter of fact, only a small proportion of soldiers receive training to this end. It has been held that trained cooks should prepare the ration and that the soldier should merely be required to consume it; but as in field service every man may be thrown on his own resources for the preparation of his food, familiarity with the simple methods of cooking is clearly essential. Unfortunately it is rarely possible, under the best of circumstances, to give such general knowledge to all—the cook being usually permanently assigned as such, and some of the men, in rotation, being detailed temporarily as his assistants. By this plan the men have the best skill in the preparation of their food that the company affords; but it not infrequently happens that the best culinary skill available in a command is by no means sufficient properly to qualify its possessor for such a position. To meet this contingency the special enlistment of cooks, with the pay and allowances of sergeants, has lately been authorized; but even this step has by no means insured the results desired. In the British army greater importance is attached to this part of the service than with us, and a special training-school for army cooks is maintained at Aldershot. This is an example which might be followed with great advantage in our own army, particularly with reference to the preparation of the ration under the conditions prevailing in the field.

Camp life necessarily dispenses with many kitchen facilities and thus diminishes the variety of dishes which may be prepared; but those retained should be served in perfect condition. The shortcomings of the camp kitchen cannot be considered as a valid excuse for bad cooking, for nothing should be attempted save what can be certainly accomplished with the facilities at hand.

While line officers are responsible for the cooking of the ration, its supervision and inspection is part of the duty of the sanitary officer. It is not expected or practicable that the latter shall minutely instruct in cookery, but he should have a knowledge of the general principles of that art, and, especially with raw troops, should have the preparation as well as the quality of the food constantly under observation. Above all things he should bear in mind that the first duty of a cook, in or out of the military service, is scrupulous cleanliness.

Means of Cooking the Ration.—The cooking-ranges, fixtures and utensils that accompany them are provided by the Quartermasters' Department. Utensils needed for the preparation of food that are not furnished by the Government can be provided by purchases made from the company or mess funds. The range supplied for garrison use is the so-called Army Range No. 4. This does not differ greatly from similar large ranges employed in civil life and requires no description; the same remarks apply also to the kitchen ware and mess crockery.

In the field the conveniences for cooking are greatly varied, ranging from the portable cooking-outfits, nearly equal in completeness of equipment to the kitchen in garrison, to the open fire over which the soldier prepares his bacon and coffee with the utensils carried on his person. Various portable stoves, ranges and ovens have been placed on the market and several varieties are used in our service. Lately, however, the Buzzacott outfits have been accepted as standard for the military service, and these are now being generally issued to troops. These outfits are made in sev-

eral different sizes and styles. In principle, the Buzzacott outfit consists of a steel frame, which serves as a skeleton stove, enclosing a stout rectangular oven composed of two sheet iron boxes, one inverted over the other.

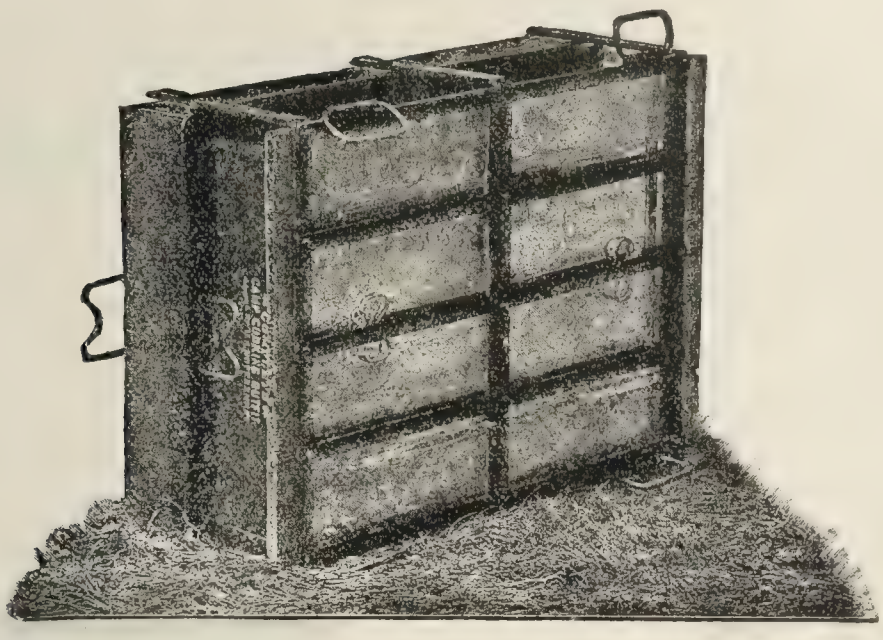


FIG. 48.—Buzzacott Cooking-Outfit, Packed.

Within this oven are packed a large number of boilers, pans and other utensils, largely on the "nesting" principle, so that comparatively little space is occupied. The outfit is complete for roasting, baking, frying, boiling and stewing, and will readily cook for 100 men—and, in an emergency, for a larger number. The roasting capacity is 150 pounds, the broiling or frying 50 pounds and the boiling or stewing capacity 32 gallons, or about one barrel. The size is 25x35x14 inches; the weight, complete, 175 to 200 pounds. In shipping, the skeleton stove fastens about the whole and permits of heavy objects being packed on top without danger of crushing. This cooking-outfit will use any kind of fuel and appears well to fulfill every requirement of field service. It cannot, however, be used except in the open air; and to meet the needs of troops who may be required to occupy houses, the Buzzacott range, furnished with a stovepipe and built on much the same plans as the cooking-outfit, is also supplied. It is of excellent pattern, has a boiling capacity of nearly two barrels, a roasting capacity of one hundred and fifty pounds of meat and a bread-baking capacity of twenty-four loaves.

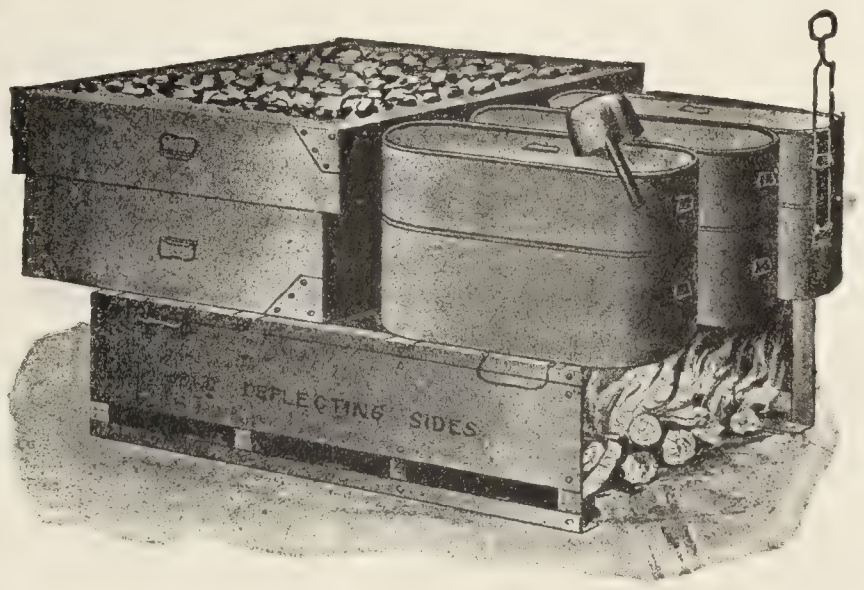


FIG. 49.—Buzzacott Cooking-Outfit in Use.

Much simpler than the Buzzacott outfits, and correspondingly less satisfactory in the results given, is a simple shield for the camp fire made of sheet iron. It is composed of a top and three sides joined by hinges.

Fuel is inserted in front, which should be to the windward; and being open, any length of wood can be used. A single joint of stovepipe is sufficient. The dimensions of this stove are 30x26x12 inches. It is obviously very portable.

The Barney steam cooker is also authorized for field use, but is rarely issued. The usual size is 18x24 inches, and when complete it has a weight of 100 pounds. It is made in two sections, one containing a soup or coffee kettle and the other a baking-pan. The former has a capacity of 13 gallons, this being equivalent to 160 cups of coffee or rations of vegetables for 100 men. The baking-pan is said to have a capacity of 75 pounds of meat. The apparatus is operated merely by inserting the legs and placing it over a moderate fire, after pouring water into the steamer. It requires no further attention. Food placed in this apparatus ordinarily requires three or four hours' cooking; it may be kept warm several hours after the fire has died out.

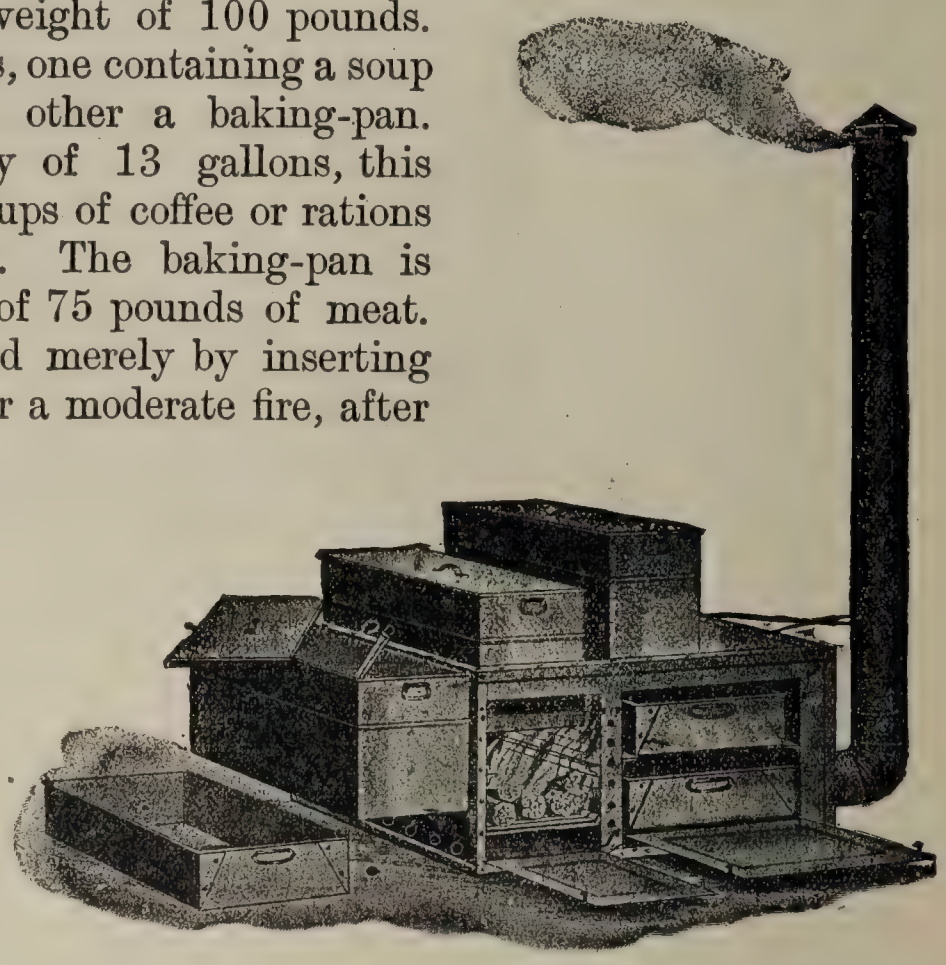


FIG. 50.—Buzzacott Range and Utensils in Use.

The Norwegian stove, used in several foreign armies, is mentioned elsewhere.

Kitchen wagons have been tried in the Austrian army, the idea being to have the food prepared when camp is reached, so that the tired troops would thus be spared the labor of its preparation. The amount of food which it was found could be furnished by such a wagon, however, was small; one wagon being required for each one hundred to one hundred and fifty men. The experiment was, therefore, with reason abandoned; since the amount of transportation required would greatly swell the wagon train and correspondingly hamper an army.

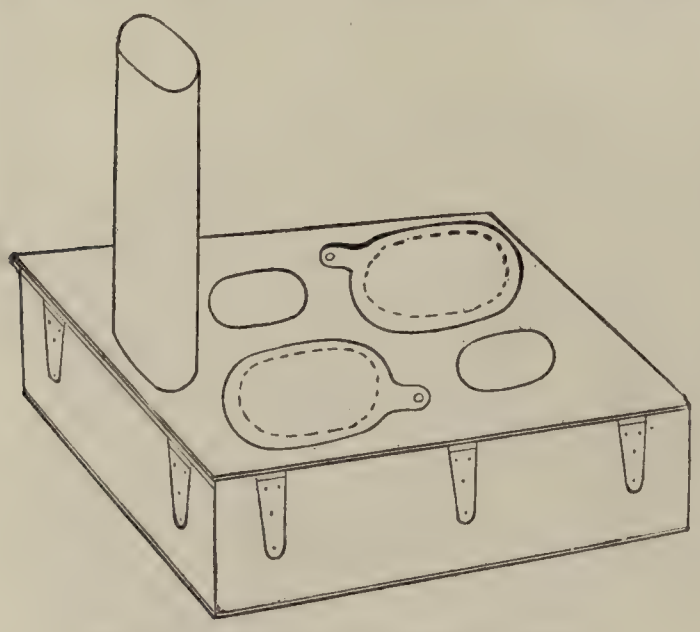


FIG. 51.—Collapsible Sheet-Iron Stove.

In the absence of any special cooking-apparatus, the simplest kitchen consists of a trench dug in the direction parallel with the wind, of such width that the kettle, when placed on it, does not project beyond it more than an inch on each side; its depth should be twelve inches at the end from which the wind is blowing, and continue this depth for four feet. It then decreases gradually to three inches at the opposite end, where a space must be left equal

to the breadth of the trench to serve as a chimney. The fire is established at the end where the trench is deep; it should not extend beyond three or four feet up the trench. The kettles are placed touching one another; dry sods should be used to stop up the chinks made by the roundness of the kettles, so that the space under them may form a flue. It is advisable to pile up sod, or with stones and earth to erect a chimney of at least one foot in height, at the end farthest from the fire. All grass around the fireplaces should be cut to prevent accidents from fire. If the command halts for more than one day, these kitchens are susceptible of great improvement; the chimney can be made of mud, or twigs and mud, and the draft may be increased by using short pieces of hoop-iron as bars, stretched across the trench to support a filling-in of clay around each kettle. As on the day following the wind may change to an exactly opposite direction, a similar trench must be dug in continuation of the former one—the same chimney being used. In this manner one chimney will serve for trenches cut to suit the wind blowing from all four quarters. The openings from these trenches into the chimney should all be closed with sod, except the one in use. In some places, where brick or stones suitable to the purpose are to be had, it is better to construct these kitchens on the ground instead of below the surface.

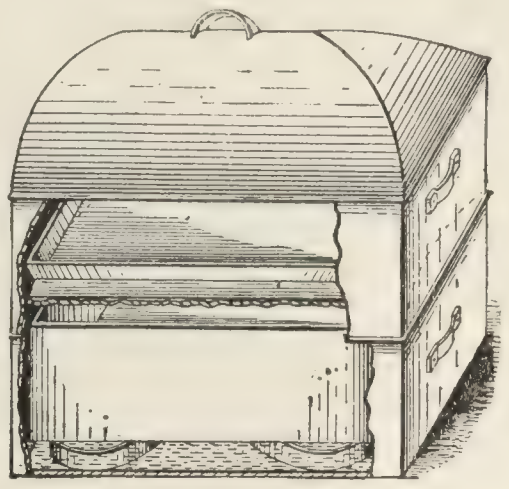


FIG. 52.—Barney Steam Cooker.

In the British service the so-called "broad arrow" kitchen is used. It is similar to the trench kitchen already described, but is much more elaborate and intended for the preparation of food for large bodies of men, regiments rather than companies. It appears to give entire satisfaction.

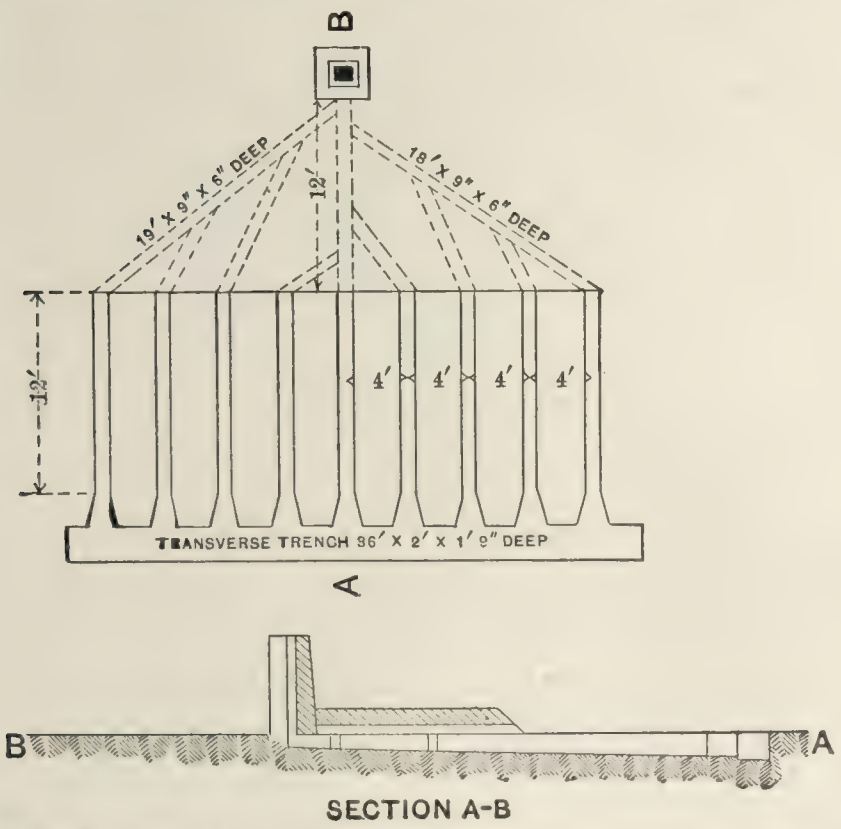


FIG. 53.—"Broad Arrow" Field Kitchen, Used in the British Army.

In well-wooded countries, two logs side by side and parallel to the direction of the wind, the fire being kindled between them, make a good company kitchen. Sometimes two logs are laid parallel about three feet apart, two notches being cut in each about ten to twelve inches apart and green logs laid transversely in these notches. The fire is built in the centre and the transverse logs give a suitable support to the camp kettles. Cranes are built by driving two green posts into the ground a foot from the fire. The upper ends, if not terminating in a crotch, should

be slightly split and a transverse pole with flattened ends inserted in them.

Ordinarily the method of improvising a cooking-place consists in excavating a trench eighteen inches wide, twelve inches deep and from four

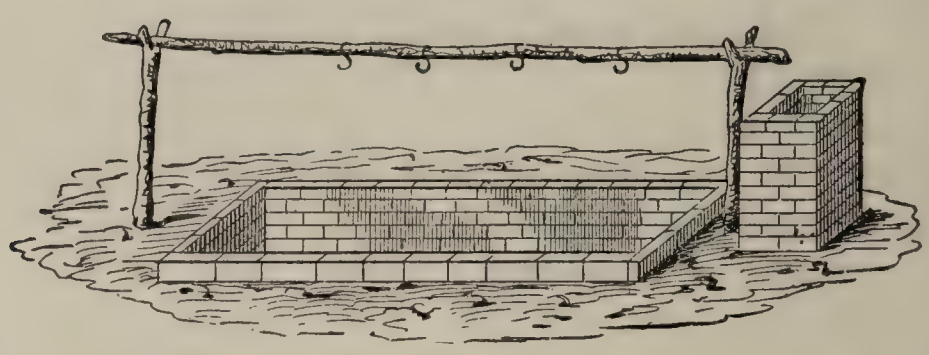


FIG. 54.—Improvised Kitchen Fire-place.

to six feet long. At each end a forked stick is placed, of equal heights, with a stout sapling, from which to suspend the kettles, extending from one to the other. This, however, is neither the best nor most economical mode, as it consumes much fuel, wastes much of the heat and causes great inconvenience to the cook. An improvement can be effected by casing the sides of the trench with brick or stone, adding a chimney at one end and, in place of the forked sticks, using iron uprights and crossbar, to which half a dozen hooks for the suspension of kettles are attached.

In a clay soil a neat, economical and convenient plan consists in digging a hole three feet square and two feet in depth, generally in the slope of a hill. From this a shaft, about one foot square and six feet in length, is run laterally about one foot below the surface of the ground. At the extreme end a shaft is sunk vertically to form a chimney; and at equal distances three similar holes are pierced of sufficient diameter to prevent the kettles from falling through when placed in position. Kettles placed over these respective holes are made to boil or simmer as desired.

Bakery Facilities.—The fact that hard bread is unsuitable for use by troops for any great length of time; together with the fact that at present

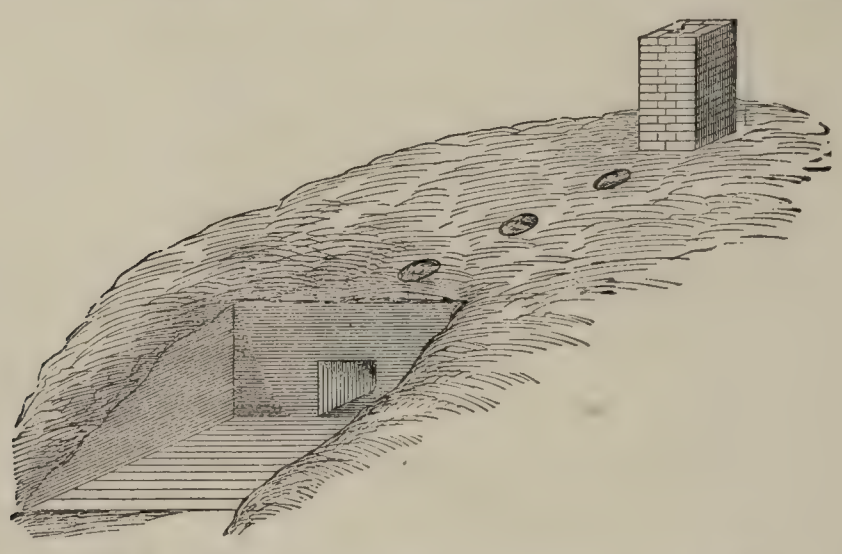


FIG. 55.—Excavated Fire-place in Side of Hill or Bank.

there is no article which can replace fresh bread in the dietary, necessitate the establishment of bakeries in the field as well as garrison. In posts, the management of the flour is taken entirely out of the hands of the company commander and all flour is turned into the post bakery, where the

bread used by the men of the entire command is prepared. The apparatus used under such conditions is similar to that employed in small bakeries in civil life and requires no special mention. In the field, however, new conditions are presented which are peculiar to the military service. For an army operating along a line of railroad a fixed bakery at the general or secondary base is often constructed and the bread forwarded as soon as baked to troops at the front. This system was employed with great success in the Army of the Potomac during the Civil War. In camps of any size or permanence iron portable ovens will usually be temporarily brought

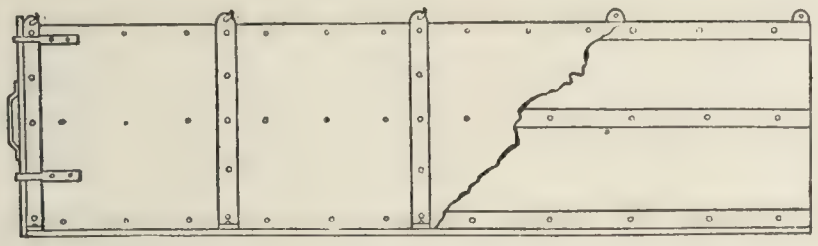


FIG. 56.—Side View of Field Oven, with Break, Showing Longitudinal Bars Inside.

into use, while for marching columns the employment of bakery wagons is practicable. For small commands, not in permanent camps, the baking must be as a rule done by company organizations. Under any conditions, except in fixed bakeries at the base, the preparation of a good quality of bread in the field will be a matter of some difficulty, and in very cold weather the production of a fermented bread is almost an impossibility.

Portable field ovens, for military use, are usually simple in construction, light in weight, easy of establishment and satisfactory as regards their output. Many varieties were used during the Civil War. At present two kinds are issued in our service, these differing little from each other except in size. The smaller oven, usually issued, is made of sheet steel strengthened with longitudinal bars and transverse ribs. The sheets composing the body are five feet long and thirty inches wide; so curved that, when their upper edges are connected and lower edges fixed in the ground, they form an arch the span of which is three feet nine inches and the rise one foot four inches. The lower edge of each sheet is bent into a flange, so as to secure a firm rest on the ground. The upper ends of the transverse ribs

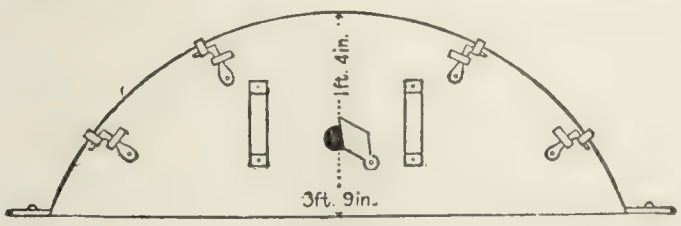


FIG. 57.—End View of Field Oven.

on one of the sheets are formed into hooks and those of the other sheet into eyes, by means of which the parts are securely united. The front of the oven is closed by a two-handled iron door, which is kept in place by means of hooks and eyes. When the soil is of clay or other favorable quality, the rear end of the oven may be closed by the natural earth; but if it is sandy or loose, a sheet-iron plate is required to close it. No chimney is necessary. When set up, the whole, with the exception of the door, is covered with earth to the depth of about eight inches. A larger quantity of earth is liable from its weight to bend the heated iron, and a smaller

quantity allows too much heat to escape. An excavation three or four feet in depth is usually made a foot or so from the door, for the convenience of the baker. Two hours are required for heating the oven at first starting, but for each heating immediately following one hour will be sufficient. A quantity of wood is placed in the oven at the extreme rear and ignited, the door being kept open to afford a draft and a vent for the smoke. Small quantities of wood are added as combustion progresses. In this way the fuel burns more freely, and the oven is heated more quickly, than if all the fuel necessary for the heating is put in at once. As soon as the oven is at a white heat the ashes are raked out, the floor is swept clean and the dough introduced in pans. The door is then closed and all interstices are filled with moistened clay or earth. The time required for each baking is about forty-five minutes. As each of the two principal pieces forming an oven weighs only about eighty-five pounds, the whole—consisting of the two sides, the door and end plate—can be easily transported, and can even be carried on a pack animal if necessary. To set up the oven no tools except a pickaxe and a shovel are required; the sides being merely placed on level ground, fastened together, the rear end closed and the whole covered with earth.

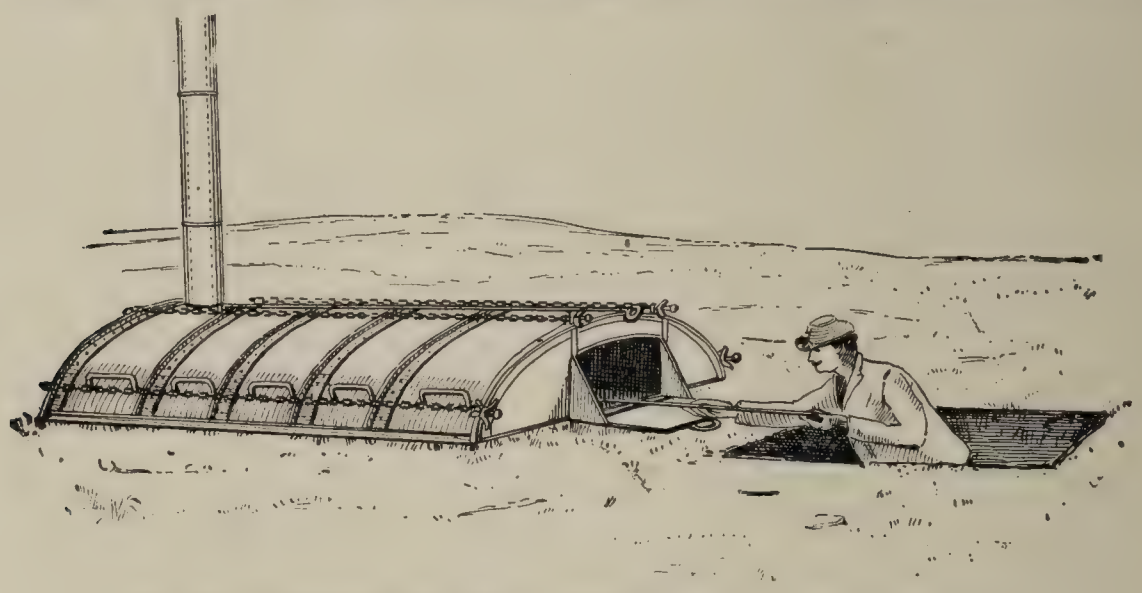


FIG. 58.—Portable Oven Used in French Army. (After Laveran.)

It can be erected and prepared for use in fifteen minutes, and if kept in constant operation for twenty-four hours can bake sufficient bread for one thousand men. By the use of two of these ovens, therefore, a regiment of a thousand men, if it make a halt of fourteen hours each day, can be supplied with fresh bread daily on the line of march.

In the French service the portable bake oven used is provided with a chimney. The sections are made with double walls for better retention of heat, are very light, so as to be transported if necessary by porters, and are capable of being operated independently. A completely equipped field bakery is attached to each army corps, together with a bakery train carrying the flour and necessary materials, and, if possible, a two-days' supply of bread.

Bakery wagons were tried during the Civil War and have also been much employed in foreign armies. In the French army they have been used successfully in Algeria and Mexico and during the Franco-Prussian War; in the German army they are also used. In construction these wagons are simple. There are two metal ovens connected with a chimney, the latter being lowered during the march. The walls of the ovens are double, or

sometimes triple, to prevent loss of heat. The interspace is packed with powdered coral, which is said to so retard the passage of heat that the hand can be held on the outside of the apparatus during the process of baking. These ovens are heated in the usual manner by wood fires kindled within them. Special wagons for the transportation of bakery supplies accompany these bakery wagons, and the baking of bread is continued during the march. The capacity of one of these bakery wagons is said to be two hundred rations of bread per hour. The recent model used in the German army is ten feet long, having a fire box for wood fire below and an oven above. The capacity of this oven is eighty loaves every one and one-half hours. The wagon has the advantage of the older models in being lighter, even if its yield is not as great.

Bread may be excellently baked in the Buzzacott range, although the size of the oven renders it scarcely sufficient for more than the needs of a single company. It is much superior to the Dutch oven, so often used. The latter consists merely in a heavy flat iron pot, with short legs and fitted with a flanged top. It is heated by coals beneath and above. Sim-

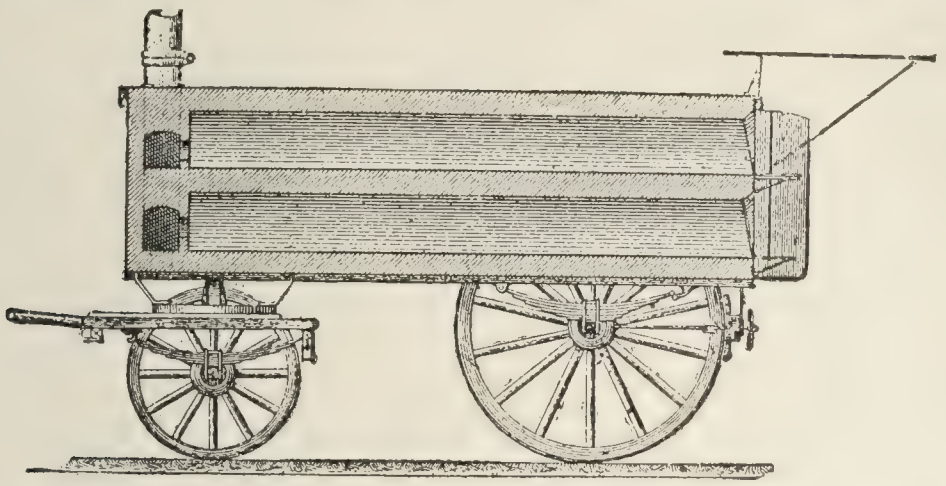


FIG. 59.—Bakery Wagon, as Used in the French and German Armies.

ilar to this method is the preparation of bread in mess pans. Of these, the rim of one is cut down so as to leave a ragged border. This pan is then filled two-thirds with dough and the perfect pan inverted over it. Both are then placed in a hole about eighteen inches deep, in which a fire has burned for several hours and from which nearly all the embers have been removed. The whole is then covered with hot ashes and allowed to remain several hours. A frying-pan may also be employed in the absence of better utensil. It is greased and heated; the dough is then put in, rolled to about one-half an inch in thickness and the whole set on the fire. The pan is shaken to prevent sticking. When the lower crust is formed the bread is removed, set on edge close to the fire and turned occasionally. Woodhull states that by this method one man with six pans can bake twenty-five pounds of bread in less than an hour.

In the absence of special apparatus for the purpose, field ovens may be improvised by excavation of the earth, or from any material available, as sod, wood or brush. The dimensions of such an oven should ordinarily not exceed 150 to 200 rations, unless the arch be of brick or stone. The ration loaf should occupy from 25 to 31 inches of floor space, preferably the latter. For 150 loaves averaging 30 square inches each the dimensions of the hearth should be 31.25 square feet. Ovens made of earth, mud, sod and frames of twigs should preferably contain not more than 100 rations.

The best oven is made in a steep bank, preferably 4 to 6 feet high. Two men with a spade and a long-handled shovel can build it, in light soil, in three-quarters of an hour. If such tools are not available, it may be constructed with trowel bayonets, entrenching tools or even with knives. To build the oven, the bank is dug down to a vertical face and a hole

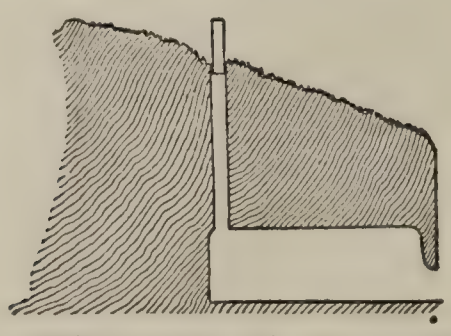


FIG. 60.—Vertical Section of Oven Excavated in Bank.

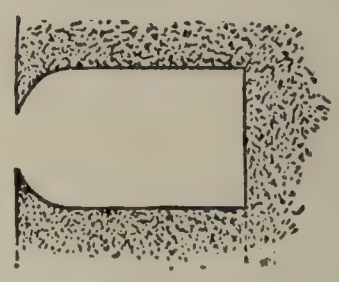


FIG. 61.—Ground Plan of Bank Oven.

excavated at the base from 4 to 5 feet horizontally, care being taken to keep the entrance as small as possible; the sides of the excavation are hollowed and the roof is arched until the floor is about 2 feet 6 inches in its widest part and the roof 16 inches high in the centre. The back end is then tapped for the flue. A hole from 4 to 6 inches in diameter will furnish a good draft, and a piece of tent stovepipe may be utilized for this purpose. It will be advantageous, before using, to wet the whole interior surface of the oven and smooth it over neatly, drying it out and hardening it with a small fire. The time required for drying out will depend upon the character of the soil; if ordinarily dry, a fire kept up for an hour will suffice. Such an oven has a capacity of about forty rations and will bake good bread in about forty minutes. With proper care it will last several weeks. Bake-pans may be used in baking, if they can be obtained; if not, the bare floor, after the ashes are removed, may be used to bake on. After the introduction of the dough, the flue and door should be closed, which may be done with logs of wood, pieces of hard-bread boxes plastered with mud, flat stones, a wet grain sack or piece of canvas. After the oven has been

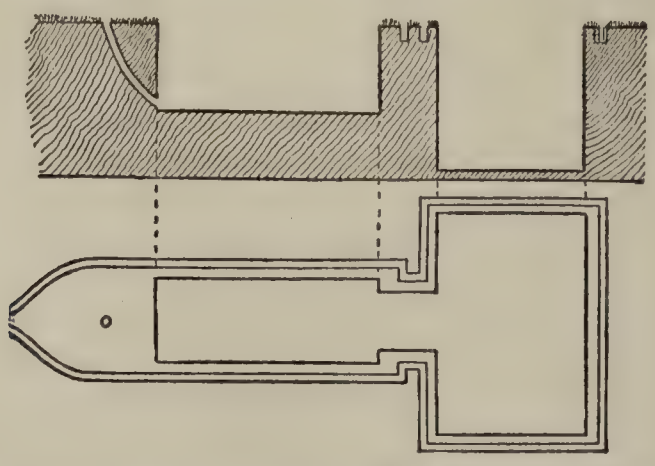


FIG. 62.—Improvised Oven on Flat Ground. Upper portion shows longitudinal section; lower portion shows plan, with ditch.

heated, the degree of heat may be regulated by means of the door and flue, opening or closing them as may be necessary.

On level ground an oven is built by digging a hole four feet long, eighteen inches wide and eighteen inches deep. Without enlarging the top, the sides are hollowed from above downward until the floor is about thirty inches wide. At about a foot from one end a trench of suitable dimensions is dug to enable a man to attend to the oven. The partition between the oven and

trench is then dug through to form the door. At the back end of the oven a small hole, slanting downward, is dug for the flue. The top of the oven is then closed in with green poles. The interspaces are filled with grass or weeds. The whole is plastered over with mud, after which a second layer of poles is added and another layer of mud. The oven and trench are then ditched to keep out storm water. Such an oven may be built by two men in one and a half hours. It is much inferior to the bank oven, but has the advantage of being easily constructed and available for immediate use. Where a camp is to remain a number of days, a bank oven may be made by digging a pit about five feet deep and then excavating its wall in the manner previously described.

Ovens may be made on the surface of the ground of mud, clay or mortar. Where mud is used, the admixture of chopped hay will give it strength. To build such an oven a rounded heap of dry earth or sand, about five feet long, thirty inches wide and twenty inches high, should be raised. This is the mould on which the oven is to be formed. Sand is more suitable for the mould than earth, as being more readily removed. Willow twigs bent over and closely wattled together, or a flour barrel laid flat and covered completely with earth, will likewise suffice to give form to the mould. A stiff mud or mortar is mixed and plastered over the mould five or six inches thick, commencing at the base. One or two days are allowed for it to dry and harden, plastering up all cracks which may appear. When nearly dry, the door at one end and the flue at the top of the other end are cut out. A small mud chimney raised over the flue will greatly improve the draft. The loose earth or sand is then carefully withdrawn from the interior. If a barrel has been used for the mould it may be burned out without damaging the oven. Two men can build this oven in three hours, but it will generally not be fit for use for two days. It will last several weeks and will prove very satisfactory. This oven may also be built dome-shaped, like the household ovens used by the Mexicans. This kind of an arch would be stronger than the semi-cylindrical form, but with the same quantity of material used would not have as great a baking capacity. The clay oven is peculiarly adapted for use when on swampy ground. Under such circumstances it may be constructed upon a platform of stones or logs covered with clay.

Dough is kneaded in the field by hand, the operation requiring about forty-five minutes. If pressed for time, it may simply be kneaded on a rubber blanket spread on the ground. A kneading-trough may be readily improvised by digging two parallel trenches a foot apart, of unequal sizes and depth. The smaller should be lined with plank and serves as a kneading-trench to the bakers, who descend into the larger excavation.

To facilitate the rising of bread in the open air, an excavation, of convenient length and width and having a depth of about eighteen inches, is made. This is heated by a small fire, after which the bread is placed in the excavation on brush-wood and the whole covered with branches, plank, hay or grass.

With respect to the amount of fuel required in the preparation of the ration, Parkes regards one-half pound per man as sufficient, using a cooking apparatus of good type. In the field, in our service, it is customary to rely chiefly upon the vicinity of the halting-place to supply the neces-

sary amount of fuel. Where its scarcity is apprehended, a small amount may be carried in the wagons. In the French army, often manœuvering in districts in which fuel is scarce, each soldier is frequently required to carry a small piece of wood, in addition to his equipment, for use when camp is established.

Meals.—In garrison, breakfast will ordinarily be about 6:30 A.M., dinner at noon and supper about 5 P.M. The latter meal might be delayed until 6 o'clock, but the soldier himself usually prefers to have a long evening to devote to his own purposes. Breakfast, in opposition to the views prevailing in foreign services, should be substantial. The last meal has been taken more than twelve hours previously, the stomach is empty, the digestion active and the work of the day is to follow. Under these circumstances the European practice of allowing the soldier merely a bit of bread and cup of tea or coffee appears quite indefensible, at least for this climate. Dinner should be the principal meal of the day, and, like breakfast, should include meat. Supper should be comparatively light. Many men, while in garrison, make a practice of taking a slight lunch at the post exchange before going to bed. It is probable that a small allowance of bread, with coffee or soup, might be issued with advantage from the kitchen about 9 P.M. to such as choose to ask for it. This would be of special value in a cold climate, particularly to members of the guard. On the march but two meals can be prepared. Breakfast is naturally early. Under favorable circumstances and in commands of moderate size a small lunch may be supplied, to be eaten while *en route*. Preparations for dinner should be at once begun when the camping-ground is reached; and this, the heaviest meal of the day, should be ready two or three hours before sunset. In the uncertainties of field service a delayed meal may be a lost one, and a salutary maxim for troops in the presence of the enemy is to eat whenever and as often as they can. Before going into action troops should be given a hearty meal, since they are thus enabled better to endure the strain of battle or pursuit.

Service of Ration.—The service of food is a matter which in our army has been given the attention it deserves. Airy and cheerful mess-rooms are provided in all barracks, and these are fully equipped with an abundance of furniture, crockery, glass and table ware—luxuries which are not even considered as attainable in most foreign armies. Abroad, the soldier eats his food at any convenient place in or around the barracks, using his own cooking utensils, as carried in the field, for that purpose. In the Russian army, food is issued in large mess-pans, out of which six or eight men eat in common. The same system is in vogue in the French army; and Laveran mentions the great frequency with which medical officers in that service have been called upon to remove fragments of bone from the throats of soldiers, these having been inadvertently swallowed by the men in their eagerness to secure a full share of food. It is obvious that such a method of messing is highly undesirable from every standpoint, and certainly would not be tolerated in this country.

Even in the field, where the camp is more than ephemeral, efforts should be made by company officers to have the men eat at a common place, to prevent contamination of the tents or their vicinity with the *débris* of meals. Ordinarily a tent-fly is soon spread for the protection of

the cook, and additional flies or a brush shelter subsequently erected for a dining-room; the men generally managing to erect rude tables and benches of rough lumber, logs or poles.

In barracks, troops usually mess as company organizations, with individual kitchens and mess-rooms. These are cared for, and the messing crockery and utensils washed, by men specially detailed for that purpose and held responsible for the maintenance of cleanliness. Usually the men employed in the dining-room and as assistants to the cook are detailed by roster, thus insuring a fair knowledge of the service of food and the management and preparation of the ration throughout the command. Bread is usually placed on the tables on platters, but meat, vegetables and coffee are served out individually before the meal is announced. This practice has several disadvantages. The portions of food are frequently cold by the time the men are seated, and hence are less palatable. Further, under this system each man usually receives at once a portion which is supposed to constitute a full meal. If the portions issued were always small the wastage would be less and the untouched remainder could be served over again. In cold weather the crockery should be warmed and no food served before the men are seated. This entails additional work on the waiters, but the extra labor is well repaid by greater contentment among the men.

General Messes.—The plan of bringing all the troops of a garrison into a general mess, for their subsistence, has been tested at a number of the larger posts in this country. When properly administered there can be no doubt that the general mess system, other things being equal, is more economical in the use of fuel, labor and the ration and offers greater variety in the matter of diet. Skilled cooks, however, are necessary to supervise the running of large general messes, and with enlisted men as cooks the troops will probably fare better when subsisted in company messes. It is much easier to find in a company a man who can cook for a small number of men than in a garrison one who has the ability to administer to best advantage the kitchen of a general mess. Where the general mess system is in vogue the barracks are free from the odors and annoyances which the presence of company kitchens entails, while the concentration for subsistence greatly lightens the labors of the sanitary officer as regards the maintenance of cleanliness, attention to proper sanitary detail, inspection of food and its proper preparation. On the other hand, it must not be forgotten that theoretically the normal existence of the soldier is in the field, where he may frequently be called upon to prepare his ration for himself. It is particularly in this respect that the general mess system is weak, for the cooking in such an establishment is carried out on so large a scale, and the apparatus provided is so totally at variance with the meagre cooking outfits available for the field mess during campaign, that the average soldier cook, who may have served a detail as an underling in such a general mess, is rarely competent at once to undertake the responsibilities incident to cooking for a company in the field. In the general mess, also, the kitchen staff is largely of a permanent character and comparatively few men are thus enabled to acquire a practical knowledge of cookery. It may therefore be concluded that, while possessing many undeniable advantages for troops in garrison, the general mess is, on the whole, inferior to the usual plan of preparing the food for each organization in its own kitchen.

In general, kitchens and mess-rooms will be better conducted if they are placed under the immediate charge of non-commissioned officers, who should be held responsible for their condition and for the proper use of the ration. No one should be allowed to visit or remain in the kitchen except those who go there on duty or are employed therein.

Foraging.—To rely on the country for means of subsistence, especially in view of the vast numbers of men which are massed together in modern wars, is ordinarily extremely hazardous. A retreating enemy will endeavor to destroy all stores likely to be of value, while the inhabitants along the line of march, whether friendly or hostile, have usually removed all available food to secret hoards for their own use. Under such conditions the army operating in a friendly territory is at a disadvantage, since it necessarily shows far greater consideration as regards the property of the civilian population than would a victorious enemy. This fact was strongly exemplified in France in 1870–71, when the French troops, operating on their own soil, were unable to obtain in the way of food a fraction of what the invading Germans subsequently wrung from an unwilling and hostile population. Foraging will often do much toward eking out deficient supplies, and, where shortage is imminent or transportation is scanty, it should be authorized. Looting, however, should not be permitted; the foraging should be done only by parties detailed for that purpose under responsible officers, and everything taken should be paid for with vouchers.

Billeting.—In this country the billeting of troops on a civilian population, for purposes of subsistence, is never required. In foreign armies, however, this procedure is common. French regulations provide, where troops are to subsist on the country, that soldiers may be told off for subsistence by the inhabitants of a town or region at the rate of four to six for each fireplace. In case of great necessity this may be increased to four to six for each inhabitant. In the German army similar regulations prevail. In the Austrian army the number of soldiers billeted may be equal to the civil population of the place. Troops billeted in this way are entitled to the usual fare of the country. Usually soldiers are not billeted on a civil population for more than three or four days.

Requisitions as a Means of Supply.—The rapidity of movements in modern warfare will reduce the value of magazine rations as a source of supply, so that the system of requisitioning when in occupation of an enemy's country will be not infrequently employed. According to Riordan the most densely populated place can furnish food and quarters for as many troops as there are inhabitants, and for a less number of troops for several days. Hazenkampf arrives at the following conclusions: (1) If the population of a given point or locality be equal to the number of troops, it can supply them for a period of four, but not more than six, days. (2) If the number of troops be half the number of the population, they can be maintained at the expense of the latter for one or two weeks. An army of sixty thousand men can be easily supplied from the means of a country which has one hundred and fifty inhabitants per square mile, but only while on the march. It must not halt at one place in a concentrated position. The following rule is given for demanding supplies on requisition: One ration daily for every three inhabitants of a well-cultivated district, and one for every six inhabitants in mountainous or poorly cultivated countries.

In cases in which an army operates in countries either devastated, uncultivated, mountainous or thinly populated, or has to fight for several days consecutively on the same ground, or has to meet the resistance or cunning of the inhabitants, it is plainly impossible for it to subsist on the resources of the country. The Germans, who made such a large use of requisitions during the Franco-Prussian war, do not appear to have had any fixed rule upon which to base their demands. Forse says: "The aim of the German officers was evidently to exhaust all the occupied towns and to make it absolutely impossible for them to assist finally in contributing toward the expenses of the war." The system of requisitions has been much used abroad, not only during the Franco-Prussian war but during the Napoleonic wars and the Russo-Turkish war of 1878. The British have frequently employed this system of supply in their expeditions, notably in the Afghanistan campaign.

II.

SUBSISTENCE AND MESSING IN FOREIGN ARMIES.

The ration of the British soldier at home stations, supplied gratuitously by the Government, consists merely of 12 ounces of meat with bone and 1 pound of bread daily. In addition, a grocery ration is provided by a stoppage from the soldier's pay, usually about $3\frac{1}{2}$ pence daily per man. This latter sum is at the disposal of the various companies in a regiment, and is usually expended on the purchase of extra bread, tea, sugar, potatoes, vegetables and other articles. Under canvas, 1 pound of bread and 1 pound of fresh meat or 12 ounces of preserved meat are allowed. In billets on the march, 20 ounces of bread, 1 pound of meat and 1 pound of potatoes or other vegetables are authorized, together with vinegar, salt and pepper. During campaign, when required by the senior medical officer, a daily ration of half a gill of rum is issued and a small deduction made therefor from the soldier's pay. At stations abroad, the ration is ordinarily the same as the issue under canvas at the home stations. In case of active operations in the field a special scale is fixed according to climate and circumstances. For this the following is accepted as a guide to be used as far as possible: One pound fresh, salt or preserved meat; $1\frac{1}{4}$ pounds bread or 1 pound biscuit or 1 pound flour; $\frac{1}{6}$ ounce tea; $\frac{1}{3}$ ounce coffee; 2 ounces sugar; $\frac{1}{2}$ ounce salt; $\frac{1}{36}$ ounce pepper; $\frac{1}{2}$ pound fresh vegetables, when procurable, or 1 ounce compressed vegetables. To this is added $\frac{1}{10}$ gill of lime juice and 1 ounce sugar on days when fresh vegetables are not issued. During campaign, if the supply of cattle is abundant, the allowance of fresh meat may be increased to $1\frac{1}{4}$ pounds. Where troops are under canvas the money value of $\frac{1}{4}$ pound of fresh meat may be expended in the purchase of cheese. Notter and Firth give the free ration and grocery ration as being ordinarily made up as follows:

Articles.	Quantity in ounces.
Meat	12
Bread	24
Potatoes	16
Other vegetables	8
Milk	3.25

Articles.	Quantity in ounces.
Sugar	1.33
Salt	.25
Coffee	.33
Tea	.16

The lack of fat, vinegar and pepper in this dietary is noticeable.

The number of men in a mess in the infantry is usually the number that each barrack-room contains. Special dining-halls are provided in but few barracks and the men eat in their squad-rooms, storing their bread and the articles of food purchased by themselves on their shelves or in their lockers. But two hot meals a day are provided, supper being merely sweetened tea with such bread or other food as may be still uneaten by the soldiers. Few men appear to take advantage of this bread and tea issue, and nearly all purchase their suppers at the canteen. The sergeants have a separate mess. Cooking is done in a regimental cook house; each company cook, usually trained at Aldershot, preparing the meals for his own organization under the direction of the sergeant cook. Cooking is generally done by baking or stewing. The British system of cooking, messing and service of food appears to be in all respects far inferior to our own and leaves much to be desired.

The food allowance in the German army is based on the recognized general principle that greater physical exertion necessitates a more generous supply of nutriment. In time of peace two rations are allowed, one being used in garrison and the other in camp or for field manœuvers. Their constituents, according to Notter and Firth, are as follows:

Articles.	Garrison ration, ounces.	Field ration, ounces.
Bread	26.47	35.30
Meat, fresh	5.30	17.65
Or Bacon	4.41	6.00
Smoked meat (war only)	....	8.82
Rice	3.18	6.00
Or Oatmeal	4.24	6.00
Peas or beans	8.12	12.00
Potatoes	53.00	71.00
Salt	....	.88
Roasted coffee	....	1.41
Brandy	....	3.53
Or Beer	....	35.30
Wine	....	17.65
Butter	....	1.76
Tobacco	....	1.41

The quantity of vegetable food given in these rations is so great as to arouse suspicion as to the correctness of the figures quoted. The amount of meat also is considerably greater than the figures obtained by the commission lately investigating the dietary of the British soldier, which placed the German meat ration in war at but 8.81 ounces.

Of the above articles the Government issues free, in time of peace, the bread ration; the other articles are provided by a stoppage from the soldier's pay amounting to about three and a half cents daily; and, as this is insufficient, the Government furnishes a supplementary subsistence allowance, determined for each garrison from the local price of foods during the preceding quarter. The bread, made of a mixture of wheat and rye flour, is furnished in kind and can be commuted only in exceptional cases. The reason for this is stated to be that the men should be well nourished and not be tempted to eat more palatable but less nutritious foods. This bread is either baked in the military bake-houses or may be directly contracted for from civilian bakers. The method of using the ration varies with the

garrison. Cooking is done with steam kettles, and the meat ration is roasted only exceptionally. Usually it is prepared in the form of a thick soup or stew. Two full meals a day are ordinarily issued, the first repast consisting usually of coffee alone. In some instances bread is used three times daily—twenty per cent. for breakfast, fifty per cent. for dinner and thirty per cent. for supper. Kitchens are provided in barracks, as are also mess-rooms. The latter are used for purposes of assembly, recreation or instruction other than at meal-times. Usually a battalion messes together. The non-commissioned officers mess separately. The following is the daily ration during war:

Articles.	Quantity in grams.	Articles.	Quantity in grams.
Bread	750	Rice, millet or oatmeal	125
Or Biscuit	500	Or Dry vegetables	250
Fresh meat	375	Potatoes	1,500
Or Smoked meat	250	Salt	25
Preserved meat	200	Coffee	25
Bacon	170		

In the enemy's country this ration may be increased by an issue of spirits.

Under certain conditions, as when troops are billeted on the march, the rations are commuted. Reimbursement in these instances is made according to tariffs based on local prices for food. Under such conditions troops are, by regulation, entitled to the usual fare of the country.

In the French service, a small amount of meat is furnished at a reduced rate by the Government, and the state also supplies bread and fuel gratis; the white bread for soup and other articles, except a small amount of coffee and sugar, being purchased from the company funds provided by the Government. In time of peace the meat allowance is 300 gm.; the allowance of "munition" bread is 750 gm., or of biscuit 550 gm. Usually the purchases from the company funds include 250 gm. of soup bread and 100 gm. each of fresh and dried vegetables per man. Laveran states that in garrison the food actually eaten by the French soldier yields about 124 gm. of protein and 760 gm. of carbohydrates. The amount of fat is too small, amounting to only about 60 gm. daily. These quantities would possess a fuel value of 4,182 Calories. Ordinarily, beef is issued four days weekly, and mutton twice. Codfish is eaten on Fridays. In the field a larger ration is issued, this varying considerably with the particular service on which troops are employed. The "strong" ration for campaign contains the following articles:

Articles.	Quantity in grams.	Articles.	Quantity in grams.
Bread	750	Fresh meat	500
Or Biscuit	600	Or Bacon	300
Bread, dried (pain biscuite)	700	Preserved meat	250
Rice	100	Lard	30
Or Dry vegetables	100	Condensed soups	25
Salt	20	Wine (occasional)	250 c.c.
Sugar	31	Brandy (occasional)	62 c.c.
Coffee, roasted	24		

As in the British service, meals are ordinarily eaten in the squadrooms, no mess-halls being provided except in a very few of the latest type of barracks. In these barracks there is one kitchen to each two squadrons,

but each squadron has a separate mess-room. Two meals a day, in addition to coffee in the morning, are prepared. Mess-gardens are encouraged wherever possible. In each company or fraction of a company a soldier is designated by turn to prepare and cook the food, usually for the period of three months. Each cook has an assistant who is relieved weekly. The sergeants do not mess with the men but eat at the canteen, the cantinières being obliged by the letter of their appointment to run a sergeants' mess at a rate fixed by the commanding officer.

In the Austro-Hungarian army the ration in time of peace consists of an allowance of black bread, amounting to 875 gm., issued in kind, and a money allowance for breakfast and dinner. The breakfast portion consists of bread, soup, tea, coffee, or brandy; the dinner portion of 190 gm. of beef and 140 gm. of desiccated vegetables, or a corresponding quantity of fresh vegetables. This ration, according to Laveran, yields 17 gm. of nitrogen. On the march, troops receive cooked subsistence in kind, consisting of 280 gm. of meat and one other article of food. In time of war the amount and constituents of the ration vary according to circumstances. The full war ration is issued during the concentration of the army after mobilization, the "*nachschub*" ration during active operations, and the reserve ration in case of emergency. The composition of these rations is as follows:

Articles.	Full ration, grams.	Nachschub ration, grams.	When on the march from mobilization, grams.	During active operations, grams.	Substitutes in lieu of articles of the full ration, grams.
Bread	700	700	250	....	Meat, 400; vegetables, 400; flour, 400; potatoes, 2,000.
Or hard bread	500	500			
Fresh meat	400	400	....	....	Pork, mutton, veal, 500; sausage, 200; cheese, 250; tinned meat, 200.
Meat conserves	....	....	290	....	Meat, 100; or flour, 140; sauerkraut, 300; potatoes, 1,000.
Vegetables (rice, barley, grits, or other dry vegetables)	140	140			
Sausage	....	....	....	200	
Salt	30	30	25	25	
Pepper or paprika	.05	.05			
Fat (lard, butter, etc.)	20	20			
Soup conserves	36	36	36	....	Flour or meal, 26; lard, 40, and caraway, 1.5.
Coffee	25	25	25	25	Tea, 6; sugar, 25; rum, 4 c.l.; or cocoa, 25; sugar, 30.
Sugar	25	25	25	25	
Brandy	9 c.l.	....	....	....	Wine, 40 c.l.; or beer, 75 c.l.; or rum or brandy, 6 c.l.
Tobacco	35.23	17.8			
Cigars (number)	6	6			

The commanders of armies, of detached corps or divisions, or even of smaller forces in the field, are authorized to change and supplement the ration, or even double it under certain circumstances. Regimental commanders are required to supplement the "*nachschub*" ration with fresh vegetables, etc., if possible, when the troops are in bivouac or cantonments.

For this purpose a special money alllowance is granted or each day that the "*nachschub*" ration is issued. This extra allowance is not granted in an enemy's country, the supplement to the ration being obtained in this case by requisition. The allowance of fresh meat is increased by 200 gm. on days when the reserve ration is issued, when beef cattle can be obtained in the enemy's country.

In the Russian army the garrison ration is composed as follows:

Articles.	Grams.	Articles.	Grams.
Flour	820	Groats	136
Or Bread	1,230	Fresh meat	205
Biscuit	820	Vegetables, variable quantity.	

When circumstances warrant the issue, the allowance of meat is increased to one pound per day. In addition to the food allowances there is also a money allowance for the purchase of vegetables and condiments, varying in value with the nature of the duty being performed by troops. Any of the above articles may be replaced by others according to the following scale: One-quarter pound of barley or oat groats equals .9 pound of peas or beans, 1.7 pounds potatoes, 2.2 pounds turnips or carrots, 3.2 pounds cabbage. In time of great hardship, according to Viry, the amount of flour may be increased to 930 gm. This quantity is much in excess of the needs of the soldier and the portion unused is either sold or used in the manufacture of the Russian beer, or "kvass." Oatmeal is usually prepared with fat, and is much liked. Kitchen gardens are usually cultivated; potatoes are little used, reliance being chiefly had on cabbage and leguminous vegetables. Fast-days are rigorously observed to the number of one hundred and fifty annually, and on these days fish soup, purchased from the company funds, is issued. There are but two heavy meals a day. Although tea is a national beverage in Russia it does not enter into the official ration but is purchased by the soldiers themselves. In time of war the ration is greatly increased according to circumstances. In the expedition against the Turcomans of Khiva the ration was composed as follows:

Articles.	Grams.	Articles.	Grams.
Meat (on the hoof)	820	Fat (lard, tallow or butter)	21
Biscuit	820	Dried peas	140
Groats	205	Salt	55
Flour	17	Also tea, sugar, and brandy.	

Notter and Firth give the larger Russian war ration as ordinarily containing, in ounces—

Articles.	Ounces.	Articles.	Ounces.
Rye bread	36.15	Groats	4.80
Meat	21.67	Butter or tallow	2.72

This is said to have the following nutritive value:

Protein, grams.	Fat, grams.	Carbohydrates, grams.	Fuel value, Calories.
164.14	117.08	520.40	3,894

The peace ration of the Italian soldier is as follows:

Articles.	Ounces.	Articles.	Ounces.
Bread	32.40	Salt	.53
Meat	7.06–10.59	Sugar	.71
Lard or bacon	.53	Coffee, roasted	.53
Rice	5.30	Wine	8.82

Reduced to its proximate principles, this diet contains 3.99 ounces of protein, 1.34 ounces of fat and 21.64 ounces of carbohydrates. The camping or marching rations are similar to the above, except that the allowance of meat is somewhat greater. The food for the troops is prepared in common; the sergeants have a separate mess. Ordinarily two meals are served daily, but when the exigencies of the service require it the food may be issued but once daily. Bread is obtained both from the military bake-houses and by contract. For field service a considerable number of rations of varying composition are authorized.

The field ration in the Swiss army consists of the following articles:

	Grams.		Grams.
Bread	750	Salt	20
Fresh meat	375	Coffee	15
Vegetables (rice, pulse, etc.)	150	Sugar	20

Biscuit may be substituted for bread; and instead of fresh meat there may be issued salt or smoked meat or bacon, canned meats, or cheese, in the following proportion: 500 gm. of biscuit for 750 gm. of bread; 275 gm. of salt meat or 250 gm. of smoked, dried or canned meat or bacon, or 250 gm. of cheese, for 375 gm. of fresh meat. When troops are exposed to very severe work or cold weather, extra subsistence may be issued, amounting in the meat ration to an increase to 500 gm., or to an addition of 65 to 125 gm. of cheese, and 3 to 5 deciliters of wine or 6 to 10 centiliters of brandy.

In the Spanish army the ration received by the soldiers consists merely of 650 gm. of bread—about 23 ounces. During peace, the soldier's pay is drawn upon to the extent of about 30 centimos daily to furnish the remainder of his subsistence, the exact amount varying in the discretion of the colonel or chief of battalion. Coffee with sugar is served at about 7 A.M., while the heavy meals of the day come at about 11 A.M. and 5 P.M. The food of the soldier naturally varies in character and quality with the region and the preferences of the commanding officer. No accurate figures as to the actual nutritive composition of the food ordinarily eaten by the Spanish soldier appears to have been made. As a rule, the various parts of the repast are cooked and served together as a mixed dish. Mess-rooms and tables are provided only for non-commissioned officers; the privates eat in any convenient point of the barracks or barrack yard. Each company usually has a different ménu, and it is a common practice, in large commands, for soldiers from different companies to come together and share their food with each other to secure the desired variety. For field-service, no less than ten different rations, entirely dissimilar in character, are authorized.

In the army of Holland the ration consists of two parts. One, the bread, is furnished gratuitously by the Government; it amounts to about twenty-two ounces. The second portion, which includes meat and groce-

ries, comes out of the soldier's pay and is purchased by company officers. Great liberty being thus given, the Government has laid down certain regulations fixing the minimum quantity of daily food which must be furnished to the soldier. These scales vary with the season. In time of war the ration is as follows:

Bread	0.75	kgm.	Or Groats	0.20	kgm.
Meat	.4	"	Rice or meal	.25	"
Or Pork	.25	"	Coffee	.02	"
Mutton	.30	"	Sugar	.01	"
Smoked or salt pork	.20	"	Salt	.03	"
Pickled fish	.50	"	Pepper	.0005	"
Potatoes	2.25	liters.	Vinegar	.04	liter.
Or Green peas	.40	"	Gin (under special circumstances)	.5	"
Beans	.50	"			

Three meals are issued daily, the breakfast usually consisting of a thick rich soup; though sometimes of coffee, bread, butter and cheese. The other meals are heavier. The sergeants mess together and contribute a considerable proportion of their pay for their subsistence.

The rations of the Swedish soldier vary largely in composition. According to Viry, the average nutritive composition has been estimated to be as follows: Protein, 185 gm.; fat, 108 gm.; carbohydrates, 671 gm.

The ration of the Turkish soldier is said by Viry to be composed as follows:

	Grams.		Grams.
Bread	850	Salt	20
Mutton	250	Onions	20
Rice	85		

The ration of the Belgian soldier consists of:

	Ounces.		Ounces.
Munition bread	26.47	Butter	0.7
White bread	.70	Lard	.35
Meat	8.82	Salt	1.00
Potatoes	35.3	Coffee	.9

This ration contains about 17 gm. of nitrogen; the fats amounting to about 40 gm. The sergeants mess together; receiving three meals a day, at two of which at least one dish of meat must be served. It is customary for the sergeants to contribute from their own resources to supplement the food provided by the Government. The men receive three meals daily. Of these the first consists of bread and coffee; the second of soup, meat and vegetables; and the third usually of bread and vegetables. Cooking is done by men detailed for the purpose.

In the Japanese army, in time of peace, each soldier receives daily about thirty-six ounces of rice, and a money allowance of six sen for the purchase of beef, chicken, pork or fish, vegetables, pea flour, tea and pepper. The ration during the late Chino-Japanese war consisted of:

	Ounces.		Ounces.
Rice	36	Or Spiced vegetables	$1\frac{7}{8}$
Chicken, beef, pork or fish	5	Preserved plums	$1\frac{1}{2}$
Or Preserved meat	$2\frac{1}{2}$	Salt	$\frac{8}{8}$
Dried meat	$3\frac{3}{4}$	Soy, miso and tea in varying quantities.	
Vegetables, fresh	5		
Or Dried vegetables	$1\frac{7}{8}$		

In hot weather, during the war with China, hard flour biscuit was substituted for rice, as the latter, when boiled, was apt to decompose. The quantity of biscuit issued is not stated. The cooking in the field is simple; the rice is boiled in large boilers, each man adding to his portion his can of preserved meat, vegetables or spice. This ration is markedly deficient in fat, a fact which was recognized by Ogata in the ration proposed by him, and which was so successful in reducing beri-beri among the Japanese naval forces. The Japanese ration is said closely to resemble that of the French native Annamite troops.

The ration issued to the military forces of the Argentine Republic is of especial interest through its marked contrast to that issued in other nations, especially Japan. This ration, according to Gache, is composed of 1,370 gm. (3 pounds) of fresh meat; biscuit, 250 gm.; rice, 56 gm.; maté, 77 gm.; sugar, 100 gm.; coffee, 36 gm. This remarkable difference in respect to meat components is to be explained by local customs of diet and the fact that meat, costly in Japan and Europe, is extremely cheap and abundant in Argentina.

In the army of Chili the ration is composed of the following articles:

	Grams.		Grams.
Meat	460	Sugar	45
Rice	120	Potatoes	100
Flour	340	Coffee	15
Beans	250	Salt	25
Onions	50	Pepper	5
Fats	40		

Any attempt at a comparison of the rations of foreign armies, either among themselves or with our own, would seem to be productive only of misleading results. Not only must quantity be taken into consideration, but also quality and the method of preparation. To these, the varying factors of custom, race and climate must be added. On the whole, the rations of foreign armies would seem to contain altogether too small a proportion of fats. As far as the garrison and peace ration provided in most armies is concerned, it usually is quite insufficient—even in some cases approaching mere subsistence diet—and the soldier is not only tacitly but officially expected to supplement it from his own resources. In most services a large share of the pay nominally allowed, as in the Spanish army, never reaches the soldier, but is expended for his subsistence by a superior officer; in other services a smaller stoppage is made against the soldier's pay, but he is practically required—as in the British army—to purchase one meal daily at the canteen or other outside source. In still other services, as in the German army, the food allowed by the state and the proportionally large stoppages from the meagre pay of the soldier are together insufficient for his proper sustenance. Lacking outside means, the soldier must, under the last conditions, either receive food from his friends, supplement his pay by performing duties for his wealthier comrades, or practically become an object of charity to the civilian population among whom he is stationed. Such an undesirable condition of affairs cannot of course exist in an army recruited purely by voluntary enlistment, as is our own, and in a country in which both the scale of wages and standard of living are high. To secure recruits by voluntary enlistment the service must be

made attractive, and in accomplishing this end an abundance of good food is a potent factor. Hence it is that the United States army is, as far as the garrison ration is concerned, by far the best fed army in the world.

For field service it is obvious that the soldier will usually have neither the opportunity nor the wherewithal to add to his diet. All nations recognize the paramount value of proper nutrition where hard labor is to be performed, and appreciate the false economy of too greatly reducing the soldier's diet under such conditions. Hence for field service the rations of foreign armies are greatly increased until, as in the case of the Austrian ration, doubled in time of war, the food allowed the soldier may even be in excess of that supplied in our own service. The statement may therefore be accepted without qualification that no civilized nation will, at the present day, attempt to maintain an under-fed army in the field. All fully appreciate that generous subsistence is an element in the absence of which there can be no efficiency, and that parsimony in respect to food will bring its own punishment through defeat.

III.

THE SEVERAL ARTICLES OF THE RATION.

Meat and Fish Components.

In the United States service meat is supplied in the fresh state as beef or mutton and in the salted or preserved condition as beef, bacon or pork. It ordinarily rests with the department commander as to how much of each kind of article the soldier shall have, and it is customary to direct that in ten days there shall be seven issues of fresh beef, two of bacon and one of pork. It usually happens, however, that much of the pork and bacon is not drawn, but the money value of the same saved and expended for articles of food of a more desirable nature. Except in the field, when fresh meat cannot be supplied, salted or preserved meats are not employed to any considerable extent. Under the best of circumstances these articles soon become distasteful, and the craving for fresh meat which early ensues is responsible for the foraging expeditions which soldiers in the field, long deprived of fresh supplies, are so prone to undertake. This craving is well understood by the authorities in all armies, and every effort is made to supply the want by providing freshly killed or refrigerated meat, in garrison or distributed from convenient points in the field, or by purchasing beef cattle to be driven with marching troops and slaughtered as required. Under all circumstances fresh meat should be supplied where it can be obtained.

Fresh Meat.—In our service it is intended that the soldier shall receive the full benefit of the fresh meat ration, and no savings in this respect can be purchased by the Government. The daily allowance of twenty ounces for the United States soldier is ample when the meat is of good quality, and is far more generous than the ordinary fresh meat ration of foreign armies. Its weight, however, is not based upon meat free from bone; and hence a deduction of ten to thirty per cent., according to breed and cut, must be made for bone from the gross allowance. In determina-

tions made by the Subsistence Department the average proportion of bone in beef, for the parts of the animal issued, was found to be about fifteen per cent. In mutton the proportion of bone is said to be somewhat higher. The waste due to bone is relatively greater in young animals, and in veal it may amount to as much as thirty per cent. As a general rule the proportion of bone in fresh beef suitable for issue will not exceed twenty per cent.

Under the influence of cooking the weight of the meat ration still further diminishes. When meat is boiled for a long period the loss may amount to as much as thirty-five per cent., while roast meat may lose an even more considerable part of its weight by evaporation and by the melting of its fat; the decrease in weight beyond a certain point being approximately proportionate to the amount of fat present. In the ordinary processes of cooking the following results have been obtained by the Subsistence Department:

	In boiling.	In baking.	In roasting.
Four pounds of beef lose.....	1 pound.	1 pound 3 ounces.	1 pound 5 ounces.
Four pounds of mutton lose ..	14 ounces.	1 " 4 "	1 " 6 "

The flesh of young animals, as veal, loses greatly in weight, forty to sixty per cent., as a result of cooking; and very great loss is also said to occur with the flesh of half-fed cattle. In cutting up the meat there is also a small waste, and it is thus evident that the fresh meat ration of twenty ounces, as delivered from the block, undergoes a diminution of about forty-five per cent. before being served—leaving the soldier only about eleven ounces of cooked flesh as a daily net allowance. Viry states that in the French army the amount of cooked meat available for the soldier will not exceed thirty-five to thirty-eight per cent. of the raw weight. He places the ordinary proportion of bone in the beef issued in the French service, known as second quality beef, at twenty-four per cent. It is true that a certain amount of the fat lost by the meat is returned to the soldier in the form of gravy; and the bones, when used in soup, possess a considerable nutritive value, especially when crushed, reckoned at about one-third that of an equal weight of beef in carbon and about one-sixth in nitrogen. The unavoidable loss is, however, considerable, and it may be accepted that the fresh meat ration, as issued from the block, ultimately affords the soldier the nutritive equivalent of not more than thirteen to fifteen ounces of bone-free meat; its value varying slightly with the economy of the cook and the method of preparation. For the American soldier, accustomed to the use of a considerable quantity of meat in his dietary prior to entering the army, the above amount will not justly be considered as any more than sufficient in quantity, so that it behooves all who are concerned with the soldier's ration to see that he receives the full benefit of the excellent quality of meat with which he is supposed to be provided.

Meat Contracts.—In this connection it may be emphasized that the present system of awarding meat contracts, covering long periods, to the lowest bidder, is distinctly opposed to the interests of the soldier and favors sharp practice on the part of the contractor. Constant watchful-

ness by sanitary officers is necessary to insure that the requirements of the contracts are properly carried out; for where competition is keen and the successful bidder secures his contract at a figure so low as to allow but a very small margin of profit, the temptation is great for unscrupulous dealers to supply troops with meat of inferior quality. It is undoubtedly the case, in many instances, that contractors bid so low that, if any unforeseen contingency arises, it is out of the question for them to supply meat of good quality at a profit. The rule of accepting the lowest bid, irrespective of other considerations, may thus frequently deter honest men from undertaking a contract for supply, which, by the stringent working of this rule, naturally falls to the less scrupulous speculator. Without the exercise of great care, beef from old or diseased animals, and from those in poor condition from long travel or hardship, will be offered for issue; while contractors who have a civil and military clientèle are prone to sell the choice cuts to outside customers, furnishing only cuts of inferior quality for the use of troops. The meat supplied is too frequently on the border line between good and bad, and officers are unfortunately too prone to pass over minor delinquencies on the part of contractors and fail to hold the latter to the strict letter of their contracts. In foreign armies the necessity of constant inspection of meat is fully appreciated; in the English, French, German and other services the senior medical officer with a regiment is required to inspect and approve all meat intended for issue to troops, and is held responsible for its good quality.

Western beef cattle are in poor condition at certain seasons, particularly after drought or following a hard winter and late spring. Meat from such animals is naturally tough and lean, and possesses an undue proportion of bone. Where beef contracts are awarded for as long a period as one year, and at a price which prevents the contractor from supplying beef from other than neighboring and often sterile ranges, the quality will be periodically subject to criticism. Stall-fed animals might with advantage be contracted for—at least during certain specified seasons of the year.

Where dressed meat is contracted for, it would be much to the advantage of troops if the practice of making local contracts could be discontinued and dealings be had, wherever possible, direct with large firms of known reliability, operating establishments at centrally located points. At these large establishments competent Government inspectors are always on hand, and would thus pass upon the quality of all meat intended for the military service, its uniformly good character being thus maintained. As far as troops located in the eastern, middle and southern states are concerned, it would seem as if this direct method of supply should in most cases entail little if any additional expense, since the profits of the local dealers, who themselves obtain most of their meat from these central establishments, would thus be largely avoided. While of importance to the welfare of the soldier at all times, it is particularly in time of war that the inspection of meat, either on the hoof or on the block, should be carried out with the greatest care to prevent knavery on the part of contractors.

Military Abattoirs.—To avoid the many disadvantages of purchasing dressed meat by contract, government abattoirs have been established in connection with some of the larger military garrisons in France, Germany and England. Where smaller bodies of troops are located near towns, the

municipal abattoirs are in many instances used by them on certain days of the week. The animals slaughtered are carefully inspected by competent officers both before and after killing, and an excellent quality of meat is thus insured for issue. As the purchasing agents of the Government usually deal directly with the cattle raisers, the profits of the middle-man are largely avoided, to the benefit of both the stock raiser and the state. This system has not been employed in our service during time of peace; but in certain instances it might with advantage be adopted.

Beef.—In the United States service, mutton is rarely issued and fresh meat is almost invariably supplied in the form of beef. The latter, next to bread, therefore becomes the most important article of the soldier's diet.

In its chemical composition, beef varies so greatly with the cut and with the condition of the animal that it is extremely difficult to formulate any averages for the whole. Analyses of some of the more important cuts, however, shown in a subsequent illustration, yield the following figures:

Cut.	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Fore and hind quarters, average.	50.5	14.7	15.8	944
Chuck	54.0	15.8	15.5	820
Loin	52.9	16.4	16.9	1,020
Ribs	48.0	13.8	24.8	1,305
Round	62.5	19.2	9.2	745
Rump	46.9	15.2	18.6	1,065
Shoulder clod	57.0	16.5	8.4	660

Contracts for the army require that fresh beef shall be good in quality and condition, fit for immediate use, and from fore and hind quarter meats proportionally, including all the best cuts thereof. Beef from bulls, stags, cows, hornless or diseased cattle shall not be delivered. The necks of the cattle slaughtered for beef shall be cut off at the fourth vertebral joint, and the breasts trimmed down; the shanks of fore-quarters shall be cut off four inches above the knee-joint, and of hind-quarters eight inches above the hock-joint. Necks, shanks and kidney tallow shall be excluded from delivery. It has been found by the Commissary Department that in a steer dressed according to contract the fore-quarters weighed 310 pounds 15 ounces, and the hind-quarters 268 pounds 13 ounces—the excess in weight of the fore-quarters being 42 pounds 2 ounces. This proportion has been found to be general; consequently, in receiving fresh beef under contract it should be expected that the proportion of fore-quarters meat to hind-quarters meat would be about as eight is to seven. As to the character of eating beef, cattle may be graded in the following order: Spayed heifer from four to seven years old; steer or bullock (never worked) from four to six years old; "free-martin," or barren heifer, not over eight years old; ox from five to eight years old; heifer from three to four years old; cow from three to eight years old.

Beef Cattle.—The purchase of animals on the hoof, for slaughter as food for troops, is a common procedure in foreign armies, many of which, as stated above, maintain military abattoirs, but the practice is comparatively rare in our own service. Under present conditions, within the United States, the supply of dressed beef to troops is usually easy of accomplishment; but

in war the reverse may be the case and the purchase of live cattle may become necessary. Before the adoption of modern processes of preservation, troops during campaign were obliged to depend on the country for their supply of fresh meat—at best an insufficient and precarious source of supply—or have recourse to herds of beef cattle provided by the commissariat and driven with the army. Where troops are operating far from railroads, or at a long distance from the base of supply, these methods may still be necessary; but they present many obvious disadvantages, as experienced in our army during the Civil War. Where a subsistence herd accompanies troops the meat soon becomes poor in quality, tough and presenting an undue proportion of bone from insufficient grazing and much driving. If marching is constant and movements are rapid, it may frequently happen that the herd is left behind and not available when hard service renders the issue of good meat most to be desired. The subsistence herd has also not infrequently become infected with contagious disease, resulting in the death of many diseased animals and the necessary slaughter of others. During the Franco-Prussian war the beef cattle of the invading Germans were largely diseased, and were credited with causing outbreaks of sickness in the population of the regions through which they passed. Wherever beef herds are maintained they should be under careful and constant inspection, and any sick or ailing animals at once separated from the others.

All meat-producing animals should be examined while living and after they are killed. Both inspections are made because there are some conditions that cannot well be detected after the animal is slaughtered, but which often have an important effect on the quality of the meat, as fever, fatigue, exhaustion, starvation and excitement. When animals are purchased in any large quantity the services of a veterinarian should be available, but in his absence the medical officer should be able intelligently to carry out the necessary inspection. This duty is by no means difficult of performance, since the sick and unsound animals are readily eliminated and sex, age, and condition are at once determined—these being the most important factors in estimating the quality of the meat. Animals should be inspected twenty-four hours before being killed. Such as have been accepted by the inspector should be at once branded or otherwise properly marked to prevent possible substitution and fraud.

Weight.—Where live beeves are purchased it is specified in regulations for the Commissary Department that animals weighing less than 1,000 pounds or more than 1,400 pounds must not be accepted except in case of necessity, when the purchase of those weighing less than 1,000 pounds is permitted. Ordinarily a net weight of 600 pounds is expected. It is required that all animals offered for sale shall be kept without food or water for the twelve hours immediately before weighing. The present method used in our service for estimating the net weight of cattle on the hoof is officially laid down as follows:

Gross weight.	Estimated net weight.
800 pounds and less	40 per cent. of gross weight.
Over 800 pounds and less than 1,300 pounds	50 " " " "
1,300 pounds and over	55 " " " "

This mode of determining the net weight is to govern only when the beeves are in condition to yield fresh meat of good quality. In the Civil

War fresh meat was generally issued upon the hoof, the net weight of the animal being at that time determined by the following rule: From the live weight of a steer there is deducted twenty-five per cent. when the gross weight exceeds 1,300 pounds, and fifty per cent. when it is under 1,300 and not less than 800 pounds. Where the beeves cannot be weighed it is directed that the animals be divided into three or more lots, graded according to apparent weight, and that from each lot an average animal be killed, dressed, trimmed and weighed.

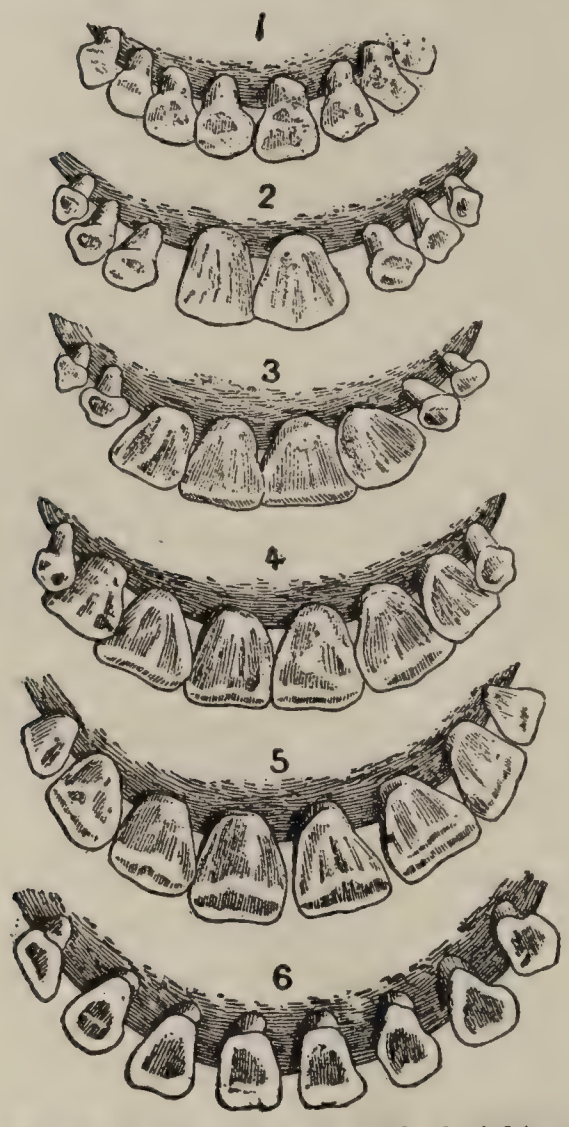


FIG. 63.—1, Lower jaw of calf of eighteen to twenty months; 2, lower jaw of animal of two years; 3, lower jaw of beef of two- and one-half to three years; 4, lower jaw of beef of three and one-half to four years; 5, lower jaw of beef at five years; 6, lower jaw of beef at twelve years. (After Lecoq.)

A satisfactory method for the determination of the weight of an animal, where scales are not available, consists in measuring the length of the trunk from just in front of the scapulæ to the root of the tail, and the girth or circumference just behind the scapulæ; then by multiplying the square of the girth by 0.08 and the product by the length, the dimensions in cubic feet are obtained; each cubic foot is supposed to weigh 42 pounds avoirdupois. The formula is $(C^2 \times .08) \times (L \times 42) = \text{weight}$; the result is in pounds avoirdupois. The skin is one-eighteenth of the weight; the tallow one-twelfth. In very fat cattle the weight may be five per cent. more, and in very lean cattle five per cent. less than the actual weight found by the above rule.

In the British service an ox is expected to weigh not less than 600 pounds, while in the French army the minimum is fixed at about 550 pounds. A fat cow will weigh from 700 to 750 pounds; a heifer should weigh at least 400 pounds. In the French army a minimum weight for cows to be accepted for food is fixed at 350 pounds. The largest and best-conditioned cattle in our own country come from the ranges of the northwest. Southern cattle, especially Florida cattle and those found in the tropics, are small and lean and their meat is stringy.

Where meat is supplied on the hoof and pasturage is abundant, troops may realize a valuable saving, in quantity and quality, by allowing cattle to recruit from the exhaustion of a long journey and gain flesh by feeding before slaughter.

Age.—The best quality of beef is found in animals from four to six years old. Before that time the maximum development is scarcely attained, while later the flesh undergoes deterioration in quality. Cows or heifers intended for slaughter should best be not more than four years old. Where veal is purchased by troops it should preferably be killed between the ages of three and five months; under six weeks of age veal is unfit for food.

In the living animal, or where the head is attached to the carcass, the age is told with great certainty by the teeth; less accurately by the horns. The temporary teeth are in part through at birth, and all the incisors are through in twenty days; the first, second and third pairs of temporary molars are through in thirty days; the teeth are grown large enough to touch each other in six months, and gradually wear and fall in eighteen months; the fourth permanent molars are through at the fourth month; the fifth at the fifteenth; the sixth at two years. The temporary teeth begin to fall at twenty-one months and are entirely replaced by the thirty-ninth to the forty-fifth month, the order being—central pair of incisors gone at twenty-one months; second pair of incisors at twenty-seven months; first and second temporary molars at thirty months; third temporary molars at thirty months to three years; third and fourth temporary incisors at thirty-three months to three years. The development is quite complete at from five to six years. At that time the border of the incisors has been worn away a little below the level of the grinders. At six years the first grinders are beginning to wear and are on a level with the incisors. At eight years the wear of the first grinders is very apparent. At ten or eleven years the used surfaces of the teeth begin to bear a square mark surrounded with a white line; and this is pronounced on all the teeth by the twelfth year; between the twelfth and fourteenth year this mark takes a round form. The appearance of the horns is less useful as a guide, but affords reasonably accurate data upon which to base an estimate of age. According to Laveran, a ridge appears at the base of the horn after the third year, with an additional ridge for each subsequent year. The rings on the horns, however, become indistinguishable in old age; besides which unscrupulous dealers may file the horns.

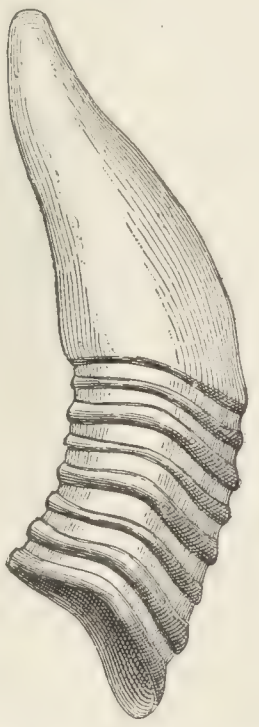


FIG. 64.—Horn of Beef Animal Nine Years Old. (After Laveran.)

Condition.—The condition of live cattle is generally told by the handling points, of which as many as twelve are given. Of these, however, but five need be mentioned, since an animal satisfactory in these points is sure to be good in the remainder. These points are the natches, or the bones by the side of the tail, the twist, the flank, the udder and the rib. The flesh on all these handling points should feel compact and firm, the twist or parts between the two buttocks should stand out prominently, the flank should be full and appear to meet the hand on passing it over the animal. The rib should be well covered with compact flesh and the cod or udder should be a large lump of firm fat. In half-fed animals the flesh will not be so firm to the touch as in fully-fed ones. To be able to properly tell the condition of a beast by handling requires some practice.

Health.—As indicating health, the inspector should note the general ease of movements; the quick bright eye; the nasal mucous membrane, red, moist and healthy looking; the tongue not hanging; the respiration regular, easy; the expired air without odor; the circulation tranquil; the excreta natural in appearance. Disease is shown by an alteration in the conditions above mentioned. When sick, the coat is rough or standing;

the nostrils are dry or covered with foam; the eyes are heavy; the tongue is protruded; the respiration is difficult; movement is slow and difficult. There may be diarrhœa, scanty or bloody urine or other abnormal symptoms. In the cow the teats are hot. The more common diseases likely to engage the attention of the inspector are pleuro-pneumonia, anthrax, tuberculosis, foot-and-mouth disease, rinderpest and actinomycosis. The nature of any of these affections, if at all advanced, is usually readily recognized.

In time of peace, or when supplies are abundant, diseased animals should invariably be rejected. In foreign countries a disease not likely to injure the health of the consumer is not regarded as sufficient reason for the rejection of a carcass. In the United States, however, people are more particular in regard to the quality and character of the food they eat than are those of any other country, and there is an almost universal sentiment against eating the meat of animals affected with any disease, whether the latter be directly communicable to the consumer or not. There is no doubt but that this practice is wise, since in nearly every diseased condition the quality of the meat is inferior. If food is scarce, the flesh of cattle affected with any of the above diseases, save anthrax, may in an emergency be eaten after thorough cooking.

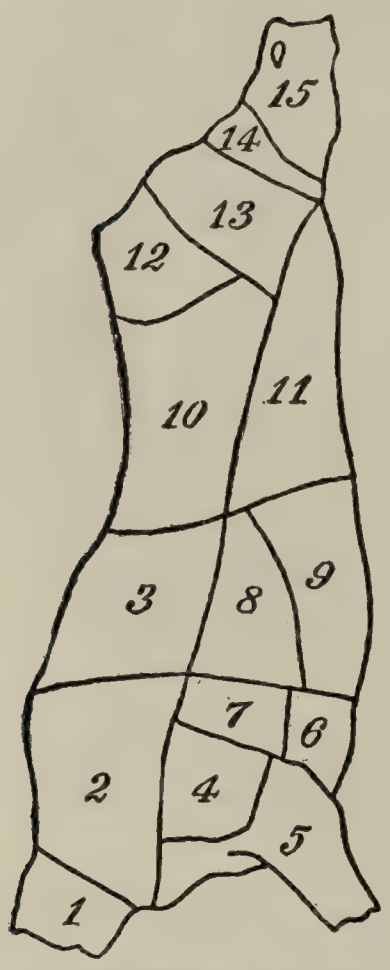


FIG. 65.—Diagram of Cuts of Beef. 1, Neck; 2, chuck; 3, ribs; 4, shoulder clod; 5, fore shank; 6, brisket; 7, cross ribs; 8, plate; 9, navel; 10, loin; 11, flank; 12, rump; 13, round; 14, second cut round; 15, hind shank.

Dressed Beef.—After an animal is slaughtered, the organs and flesh should be examined for evidence of diseases that are directly transmissible to the consumer, parasites that may be injurious, and any other conditions, which, while not directly transmissible, may render the flesh indigestible or toxic and thus produce digestive disturbances or more severe diseases. The carcass is also examined for the purpose of discovering conditions that render the meat innutritious or offensive—such as chronic wasting diseases, emaciation, old age or immaturity.

The manner of cutting up a beef, as well as the nomenclature of the cuts, varies to some extent with local usage; but the method shown in the accompanying diagram may in general be accepted as correct. For examination by the inspector the carcass is usually divided into quarters. The inspection should usually be made, in temperate climates, twenty-four hours after slaughtering; in the tropics it will frequently have to be performed immediately after dressing. With marching troops, slaughtering should be done as soon as camp is reached. The meat should be hung up for inspection, since in this way the entire surface is readily observed. If examined on a flat surface it may be safely assumed that anything of a doubtful nature which may exist will be found on the under side. Meat found to be of unsatisfactory character should be so marked as to prevent possible fraud on the part of the contractor.

The inspection of meat on the block is by no means easy of proper

accomplishment, and the sanitary officer should familiarize himself with the characteristics of good meat, qualities to be learned only by actual experience. Good meat, in general, presents the following characteristics:

The lean parts in young, well-fed, healthy animals, after exposure to the atmosphere for some length of time, should be of a bright, clear-looking, cherry-red color. Should the cut portion of any meat under inspection have been so long exposed as to become black and dried up, and the general conditions be such that there is a doubt whether the meat is according to contract, a fresh section should be made. As, however, raw meat freshly cut is always dark in color, no decision should be arrived at until the air has had at least an hour to act upon it, when, if it is as it should be, the color will have changed to that mentioned above. Pale, moist muscle marks the young or sickly animal, the dark colored the old one; the muscular fasciculi are larger and coarser in bulls than oxen. A deep purple tint is said to indicate that the animal has not been slaughtered but has died with the blood in it. This blood is objectionable, not because it is unhealthful in itself but because it favors rapid decomposition. The lean should have a marbled appearance, due to the presence of adipose material among the muscles. This marbling, however, will be chiefly found in the sections at the ribs and sirloins and will be absent from the sections of the fore and hind legs or buttocks. The fat should be reasonably abundant but not in excess, hard and firm; the lean should be full of juice and have a silky feeling to the touch; the muscles should be firm and elastic, yet not tough. The fat on a carcass is a most important item in judging beef. The exterior should be covered with bright, healthy-looking fat; the pleura, peritoneum and pelvic cavity should be well furnished and the kidneys surrounded with adipose material. In a fattened ox the fat may constitute as much as one-third of the flesh, but the amount varies with the feed of the animal. The meat should possess a pleasant, sweet taste, while the odor should be slight and not disagreeable. When such meat is placed on a white plate a little reddish juice flows out after some hours. In temperate climates the marrow of the hind legs is solid twenty-four hours after killing, and is of a light rosy red. If it is soft, brownish or with black points, the animal has been sick or putrefaction is commencing. The marrow of the fore legs is more diffluent, something like honey, and is a light rosy-red color. In general, variation from the characteristics of good meat, as noted above, will indicate flesh of an underfed, coarse or diseased character.

Age.—For determining the age of a dressed carcass no defined signs are available. It is of value to remember, however, that in the young animal the bones are small, soft, porous and of a pinkish color; but as the animal grows older the bones become large, harder, less porous and whiter in color. The inside part of the ribs is very pink in young animals, but as age increases this color fades away and the ribs at about six or eight years old become quite white. The tops of the spinous processes forming the chine are composed of gristle in the young animal, but are ossified about the age of six years. The pubes or aitch bone is only joined by gristle in the young animal, but this ossifies also about the age of six years. Before this gristle has ossified the butcher divides it with his knife in dressing the animal and the blue cartilage is plainly seen in the sides or quarter after-

ward; but after it has ossified the saw has to be resorted to. By the ninth year all the signs of youth will have disappeared, and the lean, instead of being soft and silky to the touch, will have become tough and stringy. As a rule, there will be a marked deficiency in the quantity of fat, and the carcass in general will present a gaunt, angular and ill-conditioned appearance.

Sex.—It is important that the sex of the animal, from which the meat under inspection was derived, should be determined; a matter of no great difficulty if the various points of difference, given below, have been carefully considered. In the hind quarter of the steer, at the root of the pizzle, is found the erector muscle, which is about three inches in length by one and a half inches in breadth. In the bull this muscle is much more fully developed than in the ox, and is much wider, darker in color and coarser in grain. The pizzle in the ox is small and undeveloped, not thicker than the finger. In the bull it is largely developed. It is often split and partly removed in order to make it appear of the same size as that of the ox; or it may be entirely removed and the retractor muscle left in. There is more cod fat in ox than in bull beef, and in the bull the cavity is generally seen from which the testicle has been removed. In bull meat generally, owing to the superior muscular development of that animal, the proportion of muscular tissue or lean meat is much greater than it is in the ox, and this gives the whole quarter of the bull a darker and redder appearance. The lean of the young ox is juicy, smooth and silky to the touch, florid in color and marbled with fat; but in the bull the marbling is absent, and on touch—a most valuable aid in judging of the quality of meat—the coarseness, stringiness and toughness of the texture is easily detected by passing the thumb or finger gently over the cut surface of the lean. The fat, though less plentiful in the full-grown bull, will be of a distinctly whiter color than that of the ox. No matter how well a bull is fed, the proportion of fat to lean is very considerably less than in the steer; in fact, an old bull has hardly any fat at all on his carcass, and what there is will be found almost entirely on the hind quarters. The chief distinguishing features of a fore quarter of an ox from that of a bull is the collar or crest, which in the bull is very large and muscular, requiring at least the whole hand to grasp it, but in the ox is very much smaller and can be grasped between the forefinger and thumb. The quarters themselves are narrower and slighter than those of the ox; but in general the bony structure, and especially the aitch bone, is very much more massive in the bull.

Young cows are rarely killed for beef, for if in good health they possess much greater value for dairy or breeding purposes. When young and in good condition the flesh is silky and juicy to the touch and possesses all the attributes of good beef. In distinguishing cow from heifer beef the udder is the sign usually relied upon. In the heifer this gland is but slightly developed; it is surrounded by fatty tissue and forms a uniform thick wall on either side of the flank. After the delivery of one calf the surface of the udder will be slightly soft, but the main portion will still consist of adipose tissue and the small milk-ducts will just be visible. After the second calf the udder will be partially composed of a tough, brown, spongy substance and partly of fine fat, while the milk ducts will



Fig. 3.



Fig. 2.



Fig. 1.

Fig. 1, Hind-quarter of Cow or Heifer.

„ 2, Hind-quarter of Bull

„ 3, Hind-quarter of Ox

(After Notter and Firth)

be much more prominent. As the number of calves increases, the udder becomes looser, browner and more spongy in appearance. To make the hind quarter of a cow resemble that of a heifer the udder is sometimes cut out while the carcass is warm and the skin is then skewered neatly over the excised part. The fraud is at once exposed by removing the skewers, and a quarter tampered with in this manner should be promptly rejected. It is very difficult to tell the fore-quarter of a heifer from that of an ox.

The pelvic bone of the old cow is unmistakable. As age increases, the portion nearest the udder gradually wears away and becomes narrower, while that nearest the haunch generally broadens considerably. The fat of the old cow is usually deficient in quantity and of a brighter yellow than that of young animals; though the latter fact, unsupported by other evidence, is not sufficient cause for rejection, as it may be attributable to breed or feeding. The flesh in old cows is generally coarse, dry and stringy. In the fore-quarter the chief indications that the animal is old are the bleached ribs, want of fat on the ribs and pleura, and a very prominent scapula or shoulder bone, with a hollowness or falling away on either side of it which gives a concave or "shelly" appearance to the quarter.

Quality.—Carcasses of animals that are slaughtered shortly after coming off ship-board, especially in bad weather, or have been transported long distances in crowded cars, are sometimes found to be much bruised and occasionally to have abscesses; the bruised parts may be cut out and the healthy part issued. The flesh of animals killed on account of acccidents is usually dark and discolored by reason of not having been bled, the thoracic and the abdominal walls are stained from contact with the viscera; the odor is offensive and there is discoloration from incipient decomposition. Most meat of this class should be condemned. If the injuries are localized and the animal is at once slaughtered, the carcass being properly dressed, the undamaged parts are normal in condition and may be eaten without injury. The flesh of over-driven animals is harsh in character, has a strong, peculiar odor and is wanting in that juicy characteristic noticed in good, well-fed animals which have been rested before slaughter. The color of such meat is dark, rigor mortis begins early, decomposition is rapid and the muscles are highly acid. The flesh of over-driven and exhausted animals is said frequently to produce diarrhœa when eaten. In certain tropical countries it is customary to work cattle on the yoke for some years and then fatten them for market purposes. Such animals are habitually driven with sharp goads instead of whips, and, on slaughtering, the muscular tissue is found to contain cicatricial nodules or cavities, holding pus or detritus resulting from the injuries produced by the free use of these goads.

In commencing putrefaction the color of the meat becomes paler. The consistence is altered and some parts of the meat are softer than others, tearing apart readily when stretched. A greenish tint may be later apparent and the putrefactive odor is marked. Taint in suspected meat is best found by plunging a knife or clean wooden skewer into the thickest part of the flesh and observing the odor acquired. This precaution is especially necessary in warm weather. The meat of healthy animals, when slightly decomposing, may often be eaten without danger; but occasionally it gives

rise to gastro-intestinal disorders, vomiting, diarrhœa and great depression. In some instances severe febrile symptoms occur, accompanied by marked cerebral complications. These effects are produced by the ptomaines resulting from the action of the micro-organisms of putrefaction; cooking appearing to have little or no influence in destroying the toxic properties of the ptomaine.

Fresh meat, derived from unsound animals, has not infrequently given rise to severe toxic symptoms, particularly if kept in dark, unwholesome and poorly ventilated places. The poisonous qualities of the meat appear to depend upon the formation of a ptomaine resulting from the action of a specific bacillus—the Bacillus enteritidis—first discovered by Gaertner in the flesh of a cow affected with severe diarrhœa; the meat of this animal having given rise to severe toxic symptoms in those who had partaken of it. This bacillus grows easily on ordinary media and is very fatal when injected subcutaneously into rabbits and guinea-pigs. It has since been isolated by other observers in a considerable number of cases of poisoning by bad meat. Veal appears especially liable to undergo change in the formation of ptomaines. According to Laveran, of 30 epidemics of intoxication from fresh meat occurring in France, 14 of them resulted from the use of fresh veal—a proportion extremely high when it is considered that veal is not a common staple of diet but rather an article of luxury. In one outbreak mentioned by this writer, occurring in the Seventy-second Regiment of the line, of 147 men who partook of some poorly cooked veal no less than 135 became sick; 10 cases were extremely serious and 2 deaths resulted.

Sausages, meat pies and hash, even when made from meat of apparently wholesome character, are liable to undergo fermentative changes in the formation of ptomaines, especially when allowed to stand in warm weather or placed in covered dishes, near a fire, over night. Hash prepared the night before it is to be eaten is particularly prone to such changes, and outbreaks of intestinal disturbances, varying from simple diarrhœa to marked choleraic symptoms, have not infrequently followed the use, in our own service, of such preparations. At Fort Sam Houston, in 1888, out of a company of the Nineteenth Infantry twenty-eight men were reported as having suffered from ptomaine poisoning; while at West Point and Walla Walla, in 1898, an entire company in each post was prostrated from the use of stale hash. At West Point, in 1895, fifty-four cadets were affected with ptomaine poisoning from a similar cause. Many other outbreaks of this character have also been reported. The symptoms of ptomaine poisoning usually follow rather closely on the ingestion of the meat, but may be delayed as much as thirty-six hours. In character, when severe, the symptoms closely resemble those produced by irritant poisoning and are accompanied by marked nervous depression and collapse. The ptomaines appear to resist a comparatively high temperature—and hence cooking, even when thoroughly carried out, does not render them harmless, even though it destroys the micro-organisms to which they owe their origin. It should not be forgotten, in this connection, that a return to a fresh meat diet from salt rations often induces diarrhœa, frequently very free in character. This, however, does not occur if the meat is eaten at first in moderation.

Among the transmissible affections to which beef cattle are liable,

capable of influencing the health of man, the most important are the occurrence of cysticerci, tuberculosis and anthrax.

Cysticercus Disease.—When the Cysticercus bovis is present in beef the latter is known as "measly"—the life history of the parasite being as follows: The eggs of the beef tapeworm, Tænia mediocanellata or saginata, are expelled with the dejecta of its host and do not undergo further development unless entrance be obtained to the alimentary canal of the ox. From here the embryo, liberated by the digestive juices, passes into the voluntary muscles of the animal, where it remains as the bladder-worm or Cysticercus bovis. An ox affected with this parasite may contain many hundreds of such cysticerci within its muscles. In the living animal the cysticercus is supposed to survive for several years, but it ordinarily dies about fourteen days after the death of its host; this fact having especial importance in connection with the storage and refrigeration of meat. It is killed by exposure to strong brine for twenty-four hours and is unable to withstand a temperature of 140° F. for five minutes. In ordinary salting, however, it requires some time for the brine fully to penetrate the tissues. On the flesh of the affected animal, either raw or imperfectly cooked, being taken into the alimentary tract of man, the cysticerci develop into the sexually complete tæniæ and the life cycle of the parasite is completed. The cysticerci are usually most numerous in the haunch and closely resemble those found in "measly" pork, hereafter described; but are said to be much more difficult to detect, since, according to Laveran, they rapidly disappear under exposure to the air, by desiccation, and their presence may be overlooked unless care is taken to examine a fresh piece of meat. To render the cysticerci more apparent it is frequently of advantage to moisten the surface of the meat to be examined. The head of the cysticercus of the ox is relatively larger than the cysticercus of pork; it is provided with four strong, prominent suckers, but lacks the hooklets characteristic of the cysticercus of the hog. In case of doubt the suspected cysticercus may be taken between the fingers and gradual pressure exerted, this causing the protrusion of the head, upon which the four suckers are readily distinguished. The only parasites in cattle liable to be mistaken for "measles" are Cysticercus tenuicollis and Echinococcus polymorphus. Neither of these parasites is directly transmissible to man.

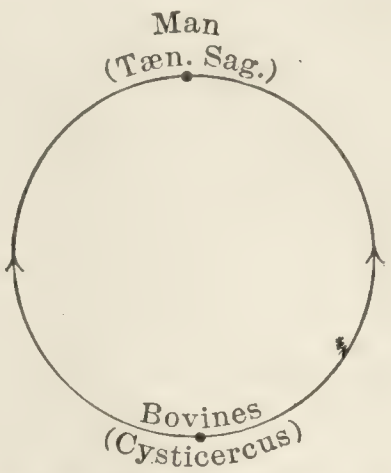
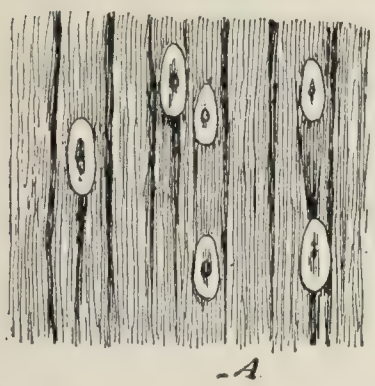
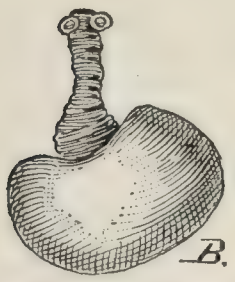


FIG. 66.—Life Cycle of the Beef Tapeworm. (After Bollinger.)



A



B.

FIG. 67.—Cysticerci bovis: *A*, in muscle; *B*, developmental form, head everted. (After Leuckart.)

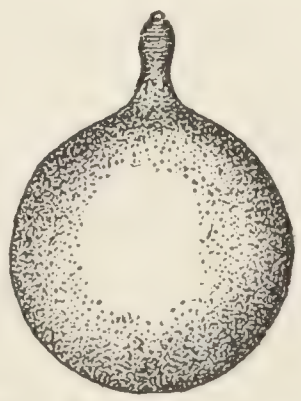


FIG. 68.—Thin-Necked Bladder Worm, Cysticercus tenuicollis, with Head Extruded from Body. Natural size.

"Measles" is said to be particularly common in the cattle of India and

Abyssinia, and Laveran states that infection by the beef tapeworm is very common among the French troops in Algiers and Tunis. The same writer states that one-fifth of the beef cattle slaughtered at the military abattoirs in Tunis are affected with cysticerci. In the United States and England the beef tapeworm is said to be much more frequent than the pork tapeworm; probably from the common habit of eating rare beef and the greater care given to the thorough cooking of pork. In the United States army, during the Civil War, there were noted 566 cases of tapeworm; while for the period of twenty-seven years, 1868–94, tapeworm was reported as occurring in 1,280 cases, giving a yearly average of 47.4. No differentiation in diagnosis appears to have been made between infections by T. mediocanellata and T. solium, but it is extremely probable that most of the cases noted were due to the former parasite; especially since trichinosis, common in American swine, was very rare in our army during the same period, this fact showing that pork is ordinarily sufficiently cooked to destroy any contained parasites. During the years 1895–97 the cases of "tænia and other intestinal parasites" numbered 114; and for 1898 there were 50 such cases reported. In the British service in India the rate of admission for tapeworm was 9 per 1,000 for 1898, 11 for 1897 and 11 for the decade 1887–96. In 1898 there were reported 162 cases of Tænia solium and 6 for Tænia mediocanellata. In the Bombay district alone, in 1898, the admissions for tænia were no less than 24 per 1,000. These figures show the importance of more careful inspection and better cooking of meat in our service; particularly since troops serving in the tropics will often be forced to rely upon native beef, well known to be largely affected with cysticerci.

There appears to be no way by which the presence of cysticerci in the ox can be definitely determined during the life of the animal. By examining the under side of the tongue it is occasionally possible to find small lumps which can be moved by the fingers and which may represent cysticerci. It is rare, however, that this method leads to practical results and no reliance should be placed on it.

Tuberculosis.—Tuberculosis is a very common affection among cattle, especially among mature animals, thus showing that the influence of contagion is more to be feared than that of heredity. It is more frequent in stabled cattle than those allowed to range freely, and varies in frequency with locality. In the United States it has been determined that from twenty to thirty per cent. of milch cows are tuberculous, even those under the best sanitary conditions. The meat inspections of Berlin showed that no less than twenty-five per cent. was tuberculous. The proportion of tuberculosis in calves is much lower than in cattle; varying according to the age and the locality, but averaging about eight per cent. In England twelve per cent. of beef is found to be tuberculous, while in Mexico as much as thirty-four per cent. appears to be so affected. In France tuberculosis in cattle does not appear to be relatively common.

Bovine tuberculosis is compatible, unless well advanced, with the maintenance of apparently good bodily condition; and it is usually impossible to diagnose the affection in the living animal by the ordinary methods of physical examination. There may be no visible symptom of the disease in the animal unless in the case of an acute attack, when there is always

fever and rapid wasting of the body. When the disease attacks the external organs, such as the udder, there is generally no constitutional disturbance; this is much more likely to be present when the internal viscera are affected, but an animal may be extensively diseased and yet exhibit no symptom to call for special attention. Since the discovery of Koch's tuberculin, however, a safe and reliable means of diagnosis is always available, and by the use of this test the proportion of affected cattle has been found to be much greater than was formerly supposed. Brewer states that all competent authorities consider the test unerring; while Pearson states that of a very large number of animals which responded to this test and which were afterward slaughtered, all presented tuberculous lesions on post-mortem examination.

According to De Schweinitz, the tuberculin employed in the Department of Agriculture is prepared in the following manner: One pound of finely chopped lean meat is added to one liter of distilled water, to which is also added one per cent. of peptone, one-fourth of one per cent. of salt, and seven per cent. of glycerin. The whole is heated to boiling and filtered. The filtrate is stored in sterilized flasks and sterilized on three successive days. After the cotton plugs of the flasks have become dry, they are removed, dipped in melted paraffin and replaced in the flasks so as to make tight stoppers. The inoculation of the media with the micro-organism is accomplished in the usual manner, using a pure culture of tubercle bacilli grown for several weeks on glycerin-agar or potato. A bit of the spongy growth so formed is detached by the platinum loop from the jelly or potato and carefully floated on the surface of the nutrient liquid; if completely immersed it will sink, and the bacilli, in the lack of oxygen, will not develop. The flask is then kept at a temperature of 98° F. until the surface of the liquid is covered with a growth of bacilli, this usually occurring in about ten days. When this is noted, the flask is carefully shaken, causing most of the growth to sink to the bottom of the liquid but leaving a small particle on the surface to serve as a nucleus for a new growth. The second growth is shaken down as in the first instance and a third growth allowed to form. This process will require six weeks to two months from the time the flask was first inoculated, and the contents are then in a condition for the preparation of tuberculin. The flask is then placed in an oven at 125° C. and allowed to remain until its contents begin to boil. It is then removed, its contents are carefully filtered and the residue on the filter paper is washed twice with distilled water. The filtrate and washings are then concentrated by evaporation down to one-fifth of the original volume. In the work of the Department of Agriculture, instead of sending out concentrated tuberculin, it has been found advisable to dilute it to such a strength that 2 c.c. will be a suitable dose for the purpose of diagnosing tuberculosis in cattle. To accomplish this dilution there is added, to the concentrated tuberculin, glycerin equal to one-fourth the original bulk of the culture liquid. This is then diluted with one-fourth of one per cent. carbolic acid, so that the volume of the tuberculin usually obtained is one-fourth more than the original quantity of culture media used. In other words, 1,000 c.c. of culture media, after the germ has been allowed to grow sufficiently long, diluted with the proper amount of glycerin and carbolic acid, should give 1,250 c.c. of tuberculin of such

a strength that 2 c.c. would be a satisfactory dose for testing an animal of one thousand pounds in weight.

Several methods of standardization of the tuberculin are employed. The amount of the tuberculin required to produce a rise of four or five degrees in temperature in tuberculous guinea-pigs of one pound in weight is noted; or the quantity of tuberculin found necessary to kill a tuberculous guinea-pig; or, again, a standard upon a chemical basis, depending upon the amount of acid which is produced by the growth of the bacilli, is used. All tubercle cultures after they are well grown show a decided acid reaction. If the reaction of the media is carefully noted before inoculation and again after the growth of the germ, it is found that the amount of acid reaction is increased proportionately to the quantity of the growth. By practice it is also found that this is approximately constant. If the value of a tuberculin made from a culture in which the acid reaction has been carefully tested is once noted, it serves as a guide for future work. In practice it has been found that healthy animals do not give reactions with large doses of tuberculin, and that as a rule tuberculous animals do not show an appreciably higher reaction with large doses of tuberculin than with medium doses; hence, while the above methods of standardization are not so accurate as those which would have to be used in weighing out a very poisonous alkaloid, experience has shown that they are sufficiently accurate for ordinary work.

If the animal is diseased, from six to eight hours after the injection of the tuberculin the temperature begins to rise from the normal, which in cattle varies from 101° to 102° F., and should continue to rise until it has reached 105° to 107°. A reaction of two degrees Fahrenheit above the normal may be considered as good evidence that the animal is infected with tuberculosis. The febrile reaction in tuberculous cattle, following the injection of tuberculin, reaches its maximum nine to fifteen hours after the injection. The temperature should be taken every two hours, beginning six hours after the injection and continuing eighteen hours. Each adult animal should receive 2 c.c. of the tuberculin diluted by the above method. Yearlings and two year olds should receive 1 to 1.5 c.c., according to size. Bulls and very large animals may receive 3 c.c. The injection is made beneath the skin of the neck or shoulders; no marked local swelling usually occurring at the seat of injection. There are, now and then, uneasiness, trembling and the more frequent passage of softened dung. There may also be slight acceleration of the pulse and of the breathing. A rise in the temperature on the day following the injection, of two or more degrees Fahrenheit above the maximum observed on the previous day, should be regarded as an indication of tuberculosis. For any rise less than this a repetition of the injection after three to six weeks is highly desirable.

It must not be forgotten that tuberculin condemns many animals in whom the disease may have but a slight foothold; a tubercular nodule, small and confined to a bronchial gland, may give rise to a reaction as intense as if the animal were affected with a generalized tuberculosis. On the other hand, some tuberculous animals, after reacting several times to tuberculin, no longer react and may be marketed as healthy. It is not clear how such fraud can be prevented.

In bovine tuberculosis the muscular tissue is less frequently affected.

Nocard states that of one hundred diseased animals examined, the lesions were found in the lungs and pleura in forty, in the lungs alone in twenty-five and in the serous membranes in twenty; the lesions in the remainder being generalized or located in the lymphatic ganglia, the genital organs, the bony system or other parts. Tumors of the lungs, variable in dimensions and often calcified, are formed by the agglomeration of tubercles. They are hard, resistant and crackle under the knife. On section, their tissue appears of an intense yellow color and is rough to the touch. Sometimes the tubercles present an obscure fluctuation and incision allows the escape of a thick, yellow, lumpy matter. The ordinary miliary tubercles are found around the tuberculous masses. The bronchial glands are also invaded where the lungs are affected; they are hypertrophied, hard and nodular, and on section appear like cheesy matter infiltrated with lime salts. The tubercles often cover the serous membranes. They appear like little tumors, round or mechanically flattened, hard, firm and white; sometimes disseminated over the serous membrane but often assuming the form of grapes, cauliflower or polyps, and many acquire considerable size. In inspecting beef carcasses care should be taken to observe the presence of the pleural and peritoneal membranes. In tuberculosis or pleuro-pneumonia there are almost invariably adhesions of the lung and pleura. Examination of the pleura will reveal this, or else there will be distinct evidence of the knife having been used in the attempt to remove the evidence of their existence. The under side of the diaphragm should also be carefully examined, and, if the coating of either this or the ribs be removed, the carcass should be rejected. No weight should be given to statements to the effect that this stripping is the result of endeavors to remove the unsightly appearance caused by "over-sticking" or "body-sticking," otherwise, unskilful bleeding; the contractor is responsible for the skill of the men he employs and must be prepared to take any loss arising from their carelessness. In the udder, tuberculosis is characterized by sclerosis. In the centre of the tissue there is a new formation of finely granular tubercles; these slowly coalescing into a more or less voluminous mass, which undergoes cheesy degeneration and calcification.

The characteristic bacilli have not infrequently been found in the fluid expressed from infected muscular tissue; they have also been observed in the blood and in the secretions of diseased organs. Feeding-experiments made with raw meat from tuberculous animals, from which the outwardly diseased portions had been removed, show that thirty-six per cent. of pigs kept on this food became tuberculous; the most frequent seat of infection in such instances being the lymphatic glands of the throat. A practical objection to the use of any parts of tuberculous animals as food consists in the fact that butchers are ordinarily careless in the cutting up of carcasses, and tuberculous matter may find its way to the knives used and be transferred by them to portions which might otherwise have remained uncontaminated. It has been shown also that even when the disease is localized the blood may contain bacilli, and in this way the meat may be throughout a source of danger. Woodhead experimented in roasting and boiling meat smeared with tuberculous matter and found that rolls of such meat, over three or four pounds in weight, were not sterilized by the ordinary means of cooking. Roasting was the least and boiling the most effective

method of destroying the bacilli. As a corollary to the points brought out above, the necessity for the thorough cooking of fresh beef, in all instances, becomes evident.

An official decree was promulgated by the French Government in 1888 forbidding the sale of tuberculous meat: (1) If the lesions were generalized; (2) if the lesions, though localized, had invaded the greater part of an organ, or were manifested by an eruption on the walls of the chest or of the abdominal cavity; such flesh was not to be used for feeding animals but must be destroyed. In Austria, when the affection is localized the remaining meat is passed as healthy. According to a recent Russian rescript, the flesh of tuberculous cattle is looked upon as dangerous to health either when the flesh contains tuberculous nodules or when the tuberculous animal is in poor condition, even if no such nodules are present in the flesh. For the military service, in time of peace or when an abundance of provisions can be secured, the flesh of animals which react to the tuberculin test, or which present the characteristic lesions of the disease, even if slight, should be rejected. In time of scarcity the apparently sound portions of meat of slightly affected animals, if otherwise in good condition, need not necessarily be condemned—but special care should be taken to insure thorough sterilization by cooking. When the lesions are generalized, the flesh of tuberculous animals should under no circumstances be used as food.



FIG. 59.—Bacilli of Anthrax in Blood. (After Abbott.)

Anthrax.—Anthrax occurs in cattle, sheep, horses and sometimes pigs. The disease is rapidly fatal and the affected animal may die in a few hours. The specific micro-organism associated with this disease, the Bacillus anthracis, is found chiefly in the blood and spleen of affected animals. It is rod-shaped, multiplies by division, and when injected into other animals produces the characteristic symptoms of the disease. In animals affected with anthrax, the liver, kidneys and spleen are congested. The spleen is enlarged, dark and frequently found to be ruptured. In the more localized affection, "black quarter," there are general hemorrhagic effusions into the subcutaneous or intermuscular tissues of the affected member. When boils and carbuncles form they are at once recognized.

The flesh of animals affected with anthrax presents in high degree the appearance of meat taken from an animal sick with fever, but the specific nature of the condition cannot always be detected by mere inspection. An examination of the blood under the microscope shows the characteristic micro-organism; but the examination must be made shortly after death to prevent the bacilli of anthrax being confounded with the common bacilli of putrefaction, which develop with extraordinary rapidity. In the blood the bacillus of anthrax is short and rod-like and does not develop into the long filaments seen in artificial cultures.

Anthrax is particularly dangerous because the germs circulate in the

blood and reach every portion of the body. They are certain to be in every part of the meat taken from the carcass. Further, the bacilli of anthrax form spores when the carcass is dressed and the oxygen of the air comes in contact with the meat. These spores resist a very high temperature and may not be destroyed by cooking. It has been claimed by some that the flesh of animals affected with anthrax, if well cooked, is not dangerous; and it is certain that such flesh has on several occasions been eaten with impunity. Its manipulation, however, is fraught with great danger prior to cooking, and many instances have occurred in which inoculation from the carcasses of diseased animals has taken place. Many cases have also occurred in which the flesh of animals affected with anthrax has given the disease; and inoculations made from the centres of affected roasts or steaks, after cooking, have almost invariably given positive results. Not only should the flesh of animals affected with anthrax be rejected as food, but it should be carefully destroyed, preferably by fire.

Actinomycosis.—This disease, also known as "lumpy jaw" in cattle, is ordinarily at once recognized by the eye from the characteristic deformity of the jaw which it produces. In doubtful cases the nature of the disease is readily determined by the microscope. The disease may also attack the lungs and bones. When the affection is advanced, the emaciation of the animal is usually great and the flesh is unfitted for food. In the early stages, when the affection is distinctly localized, the quality of the meat is not seriously impaired. The disease appears to be particularly common among range stock.



FIG. 70.—Actinomyces.

Other Diseases.—In cattle-plague, or rinderpest, the meat is seriously affected and is quite unfit for human consumption. In the sieges of Strasbourg and Paris, however, in 1814, many of the animals used as food had rinderpest and yet no evil consequences apparently resulted. This disease was extremely prevalent among the beef herds accompanying the invading Prussians in 1870–71, and many animals died from this cause. It is understood that, where possible, the German authorities made no use of the meat of such animals, regarding it as being of a dangerous character.

Texas fever is a common disease of cattle in the United States. The appearance of the meat is that induced by any febrile affection. The flesh is undesirable as food; but it may be used without harm, after thorough cooking, in an emergency.

Epidemic pleuro-pneumonia is a disease peculiar to cattle, and is a contagious inflammation of the lungs and pleura; it has never been transmitted to other than bovine animals. Its effects are localized in the lungs alone, and even in these organs the disease is a limited one. In the advanced stages, and when a large area of lung tissue is destroyed, with extensive pleurisy, the flesh becomes altered in color and consistence. Notter and Firth advise that the carcasses of animals affected with pleuro-pneumonia be passed as innocuous, if they present no departure from natural conditions.

Acute rheumatism in cattle is sometimes known as "joint-ill" or

"joint-felon." The serous fluid effused into the joints may become purulent, and abscesses may sometimes be found in the neighborhood of the affected joints. The meat becomes dropsical and the carcasses of animals so affected are totally unfit for human food.

Laveran, Notter and Firth and others give a number of instances in which typhoid fever has apparently followed the use of meat of bad quality. In such cases the typhoid baccilli must have subsequently gained access to the blood and found conditions favorable for their development. It is, of course, impossible, in the light of our present knowledge, to admit that the meat of a diseased animal is capable of directly originating true typhoid.

The flesh of feverish animals undoubtedly contains an abnormal quantity of leucomaines and perhaps of toxines, which are liable to affect the digestive organs, particularly in hot weather, and to cause illness in the consumer which is mild or severe in the latter, according to his condition at the time of partaking. According to Miller, meat derived from animals affected with febrile diseases is more or less dark and of a dull tint; the adductor muscles of the thigh usually being gray, earthy or yellowish. The serous membranes of the abdomen and chest are furrowed with hypostatic discolorations of a gray or livid color; a purplish discoloration of the loins is rarely absent. The fat shows vascular injections, giving the appearance of being streaked with wine. The smell is unpleasant and cadaveric, especially on incision of the thighs and shoulders. The muscular tissue is lacking in firmness, and in long-standing diseases the tissues are bathed in serum; the flesh is wet and pale, and rigor mortis does not readily take place. Such meat has a mottled appearance, readily "pits" on pressure and has not the elasticity of ordinary flesh. Meat of this character should invariably be rejected in time of peace; in severe straits it is better to issue it than allow troops to starve. It is said that melted fat is sometimes rubbed over the carcasses of thin and diseased animals to give the characteristic glossy look of health.

When medicines have been given, diseased meat may present the odor of physic, very evident when the meat is chopped up and drenched with hot water. Meat of this character has been known to produce in man the characteristic symptoms of the medicine administered.

Mutton.—Fresh mutton, in the same quantity as beef, forms part of the legal ration. It is by no means suited for use as a steady diet, and only as an occasional issue is it relished by troops. Even when mutton of the best quality is available the issue of beef is almost always preferred by the men. A sheep yields about sixty per cent. of flesh available as food. A full-grown animal will weigh from sixty to ninety pounds, but the difference in breeds, in this respect, is very great. Sheep under fifty pounds should not ordinarily be received, since those under this weight tendered for issue are likely to be of inferior quality. The chief characteristics of good mutton are almost the same as in beef; and the general indications as to sex in sheep can be told much the same way as in cattle. The ram in relation to the wether presents much the same appearances as the bull in relation to the ox. The pizzle of the ram is about twice as thick as the ordinary lead pencil, while the pizzle of the wether is not more than half that size. In the ram the neck is very broad and massive as compared with that of the wether or ewe. The thick neck in the ram

corresponds to the crest of the bull; and the butcher may remove it and attempt to pass the remainder as contract mutton in the same way as the neck of the bull is sometimes cut off with a view of masking the sex. Carcasses of mutton mutilated in this manner should be unhesitatingly rejected. In live animals, or where the head is attached to the carcass, the age may be told with accuracy. The temporary teeth begin to appear in the first week and fill the mouth at three months; they are gradually worn and fall at about fifteen or eighteen months. The fourth permanent grinders appear at three months and the fifth pair at twenty to twenty-seven months. A common rule is "two broad teeth every year." The wear of the teeth begins to be marked at about six years. Sheep fit for slaughter should always have a clean, even set of teeth; in the British army those with broken teeth are rejected. Should the back of a carcass present a generally discolored and veined appearance it is probably the result of age and want of condition, and the meat should be rejected. It very frequently happens that mutton tendered by contractors is extremely fat, the proportion of fat to lean being so great as to give rise to complaint on the part of the men. Mutton suet suffers a large wastage in cooking; further, it imparts a disagreeable odor and tallowy taste to the meat.

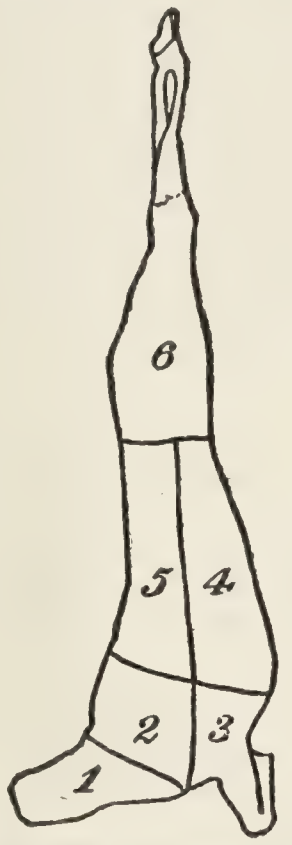


FIG. 71.—Diagram of Cuts of Mutton. 1, Neck; 2, chuck; 3, shoulder; 4, flank; 5, loin; 6, leg.

The amount of fat on a carcass may be determined, without cutting it through, by inspecting the region of the shoulders. If a bluish tinge is discernible the proportion of fat is not too great. If, on the other hand, this tinge—which is the lean showing through the covering of fat—is absent, the carcass is too fat, and the contractor should be required to strip off some of the covering of the back as well as the surplus fat about the kidneys. It is best to see personally that this is done, since otherwise only a very superficial trimming will take place. Should the contractor refuse to remove the surplus fat the carcass should be rejected. The average chemical composition of mutton is as follows:



FIG. 72.—Distomum Hepaticum.

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
43.8	16.3	22.2	1,152

The diseases affecting sheep are similar to those of cattle. Of these anthrax is the most important. Sheep also frequently suffer from acute pulmonary troubles, hæmaturia and other diseases. Of the chronic lung affections, one of the most important is the so-called phthisis, which is produced by the ova of strongylus filaria. The entozoön has not yet been found in the muscle, and the meat is said to be good. The Distomum hepaticum is frequently found in the livers of sheep, which may contain large numbers of this parasite. The number of cases of human infection by this

parasite are not large, but they are sufficiently numerous to indicate that they may be the cause of severe, though not often fatal, disorders. The affected liver should in all cases be destroyed, and the carcass condemned if it be deteriorated in quality; this being usually the case in advanced stages of the disease.

The flesh of a young, well-fed goat which has been properly castrated when young, or of a maiden female goat, is so much like mutton that it is extremely difficult to tell the difference when cooked.

Pork.—The chemical composition of some of the more important cuts of fresh pork, as purchased, is as follows:

Cut.	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Ham	45.1	14.3	29.7	1,520
Loin	40.8	13.2	26.0	1,340
Shoulder	44.9	12.0	29.8	1,480

While not included in the ration, fresh pork at contract price for beef will give pleasing variety and prove an economy when it can be kept. The lard may be rendered and all unconsumed grease preserved for culinary use, thus saving an otherwise necessary purchase from the commissary. Under-done pork, however, may cause erythema and urticaria, and such pork is always a source of danger through the animal parasites which it may be in a condition to transmit. The flesh of apparently healthy pigs has not infrequently caused diarrhœal outbreaks, which at times have even assumed a choleraic character. In 1896 a severe outbreak of this character occurred at West Point, affecting twenty-five men.

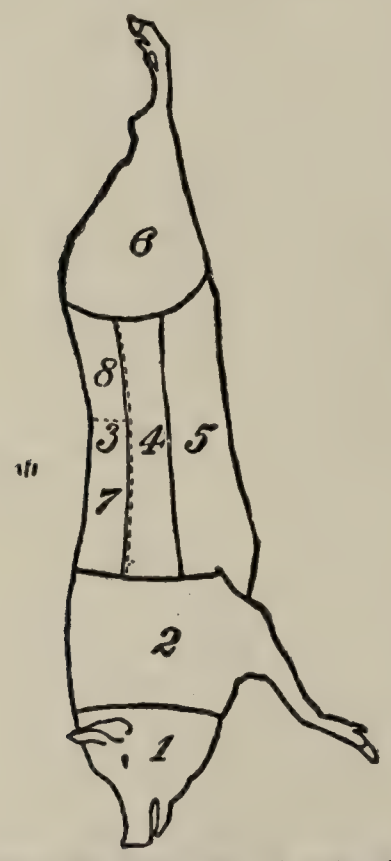


FIG. 73.—Diagram of Cuts of Pork. 1, Head; 2, shoulder; 3, back; 4, middle cut; 5, belly; 6, ham; 7, ribs; 8, loin.

Hogs, when full grown, weigh from one hundred to one hundred and eighty pounds or more, and yield from seventy-five to eighty per cent. of available food, of which as much as one-half may be fat. Old or diseased swine should be rejected. The age of the pig may be told up to three years by the teeth; after that there is no certainty. The temporary teeth are complete in three or four months; about the sixth month the pre-molars, between the tusks and the first pair of molars, appear; in six to ten months the tusks and posterior incisors are replaced; in twelve months to two years the other incisors; the four permanent molars appear at six months; the fifth pair at ten months; and the sixth and last molars at eighteen months.

Hogs are frequently kept by companies at military posts, being fed on kitchen refuse and a certain amount of grain. This practice has its advantages from an economic standpoint, but the styes and their surroundings are almost invariably allowed to lapse into such bad sanitary condition as

to render the keeping of hogs by troops quite inadvisable. The flesh of swine fed on garbage is quite inferior to that of grain-fed animals; and Gamgee states that pigs fed on flesh have a peculiarly soft, diffluent fat and emit a strong odor from their bodies. The pig is not infrequently attacked by swine fever; more rarely by anthrax. Cobbold showed that the flesh of the pig, especially the fat, sometimes contains a large parasite, Stephanurus dentatus. The worm is at first free and then encysted; the cyst is large and may be one and three-fourth inches in length and one-half inch in diameter. The full-grown worm may be as much as one and one-half inches in length. Three to six eggs are found in the cyst; the young worms migrating into the surrounding tissue after hatching. This parasite is not known to induce disease in man, although its presence in flesh intended for food is certainly undesirable and may be a cause of apprehension to inexperienced inspectors. Its true nature is readily determined by the microscope.

Pork Measles.—The eggs of the pork tapeworm, or Tænia solium, after being expelled from the affected person, are not infrequently taken up by the hog. In the latter event the contained embryo is liberated, passes into the muscular structure of the animal and becomes metamorphosed into the bladder worm, or Cysticercus cellulosæ, giving rise to the appearance known as "measles." The embryo remains in the flesh until the death of the animal acting as host, or until it passes with the flesh of the animal, used as food, into the stomach of man, when it develops into the mature tapeworm identical with that from which its life cycle was begun. It should not be forgotten that the eggs of the Tænia solium, when taken in by man, undergo development the same as in the hog; man thus serving as the intermediate host of the cysticerci. As showing its frequency, Stiles states that the proportion of cases of Cysticercus cellulosæ, occurring in cadavers dissected in Berlin, fell from 1:31 before the introduction of meat inspection to 1:280 after a system of meat inspection was instituted. Where the number of cysticerci is small the resulting symptoms are insignificant and obscure. Where the number of parasites is large the condition of the individual acting as host may become serious.

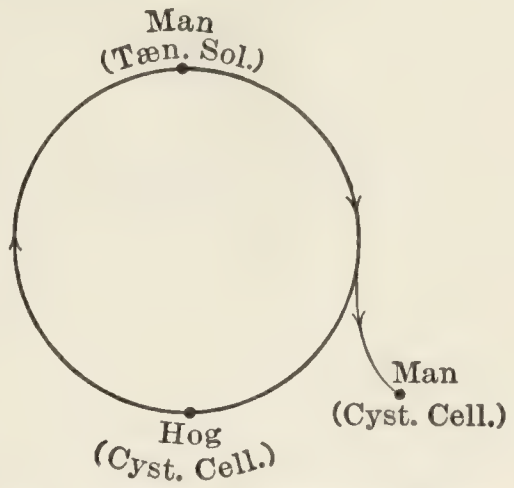


FIG. 74.—Life Cycle of Tænia solium. (After Bollinger.)

Satisfactory statistics as to the proportion of pork measles in American hogs are lacking. During life there are few indications of the existence of cysticerci in the animal. The only positive sign to be obtained is in the mouth, where the cysts may sometimes be detected on the base and sides of the tongue, or between this and the lower jaw. According to Laveran, these cysts may be caused to disappear by pricking with a needle; he stating that this practice is not infrequently resorted to by unscrupulous dealers. The body of the affected animal may have a soft, flabby feeling, and on firm pressure a crackling sensation may be imparted to the fingers. The latter signs are unreliable.

"Measles" in pork are readily recognized by the eye when the cysti-

cerci are numerous. These appear in the flesh as small, somewhat elongated gelatinous cysts, usually about the size of a pea, lying among the muscles. The cysts may be so numerous as to cause the flesh to crackle under the knife. Sometimes they are present in the liver in large numbers, giving that organ a mottled appearance on section; and Stiles states that as many as twenty thousand may occur in a single carcass. They are readily enucleated by pressure, leaving a cavity. When the meat is cooked, the cysts become opaque and pearly white. "Measly" pork has a pale, flabby appearance and is soft and apparently dropsical. The tongue, heart, intercostal muscles and neck are the parts most frequently affected,

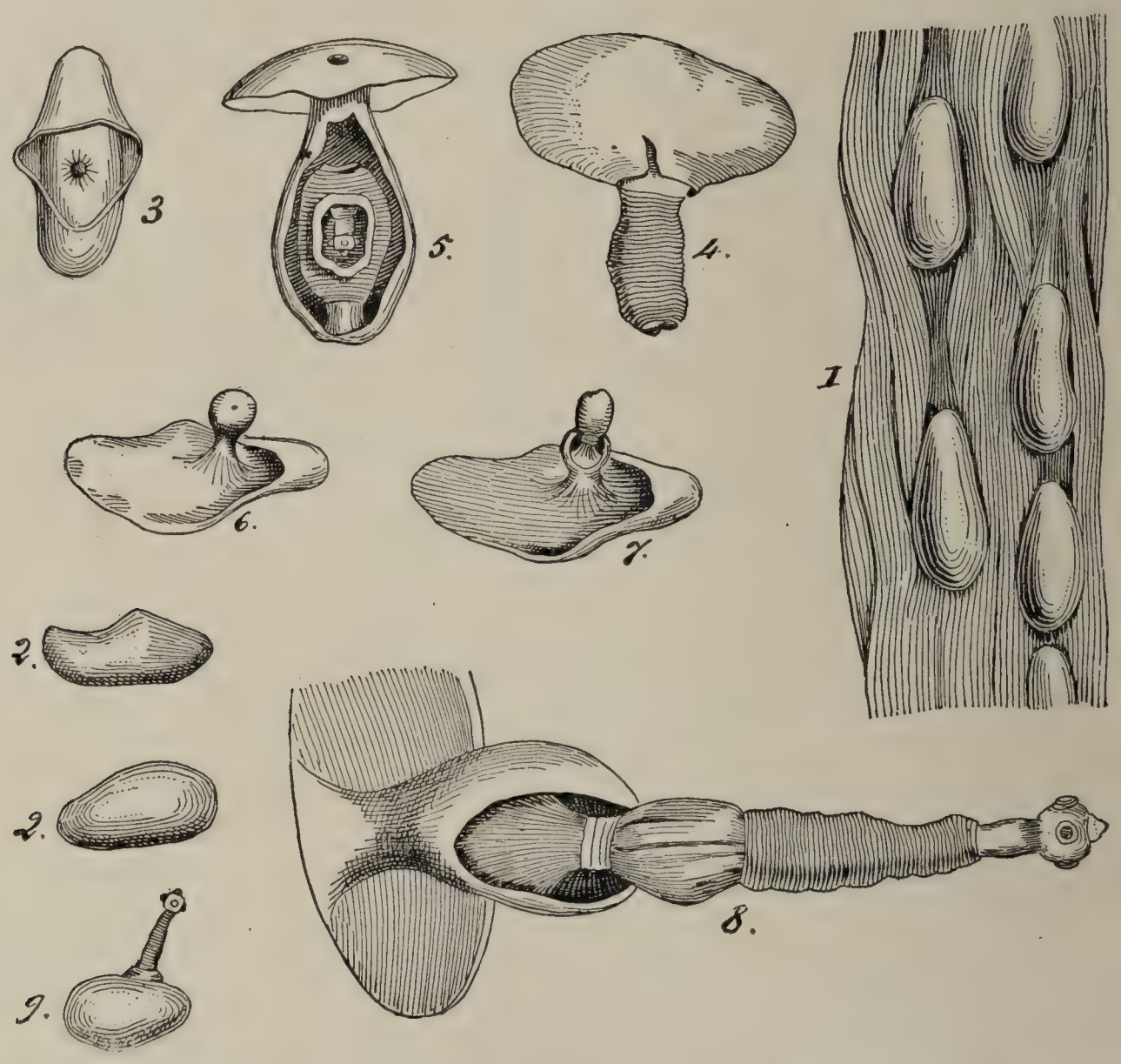


FIG. 75.—1, Cysticerci in muscle; 2, cysticerci removed from muscle; 3, external coat opened to show parasite; 4, body of parasite extruded from cyst; 5, longitudinal section, showing parasite in situ; 6, external coat opened to show inner lining containing parasite; 7, 8, inner coat cut open and parasite extruded; 9, cysticercus, with head, neck and body outside the cyst. Enlarged. (After Davaine.)

and these are the regions to which the attention of the inspector should be especially directed. As above stated, the cysts, though variable in size, are ordinarily readily visible to the naked eye; and in all cases their nature is easily determined by the microscope. The smallest cysticercus observed by Leuckart in the pig was about $\frac{4}{100}$ of an inch long and $\frac{3}{100}$ of an inch broad; but they are generally much larger and may attain a length of three-fourths of an inch. Living specimens of Cysticercus cellulosæ have been found in pork twenty-nine days after slaughtering—but after fourteen to twenty days of cold storage the parasites are said to be dead. More ob-

servations are needed on this subject. Cooking ordinarily kills cysticerci, but the meat must be well done throughout. Exposure to a temperature as low as 125° F. for the period of five minutes is said to destroy the vitality of the parasite, and the temperature of well-done meat must always attain this point. Cysticerci are killed by hot, not common, smoking, but salting does not have this effect. "Measly" pigs are said to salt badly. Old and rusty pork is frequently termed "measly;" but this term, in the absence of the characteristic cysticerci, is incorrect. Pork containing cysticerci should invariably be rejected as being unfit for consumption by troops.

Trichinosis.—The presence of the Trichina spiralis is by no means uncommon in swine, the proportion being generally considered as about two per cent. in all animals raised in this country—and this fact has served as an excuse for the exclusion of American pork from certain foreign markets. Of all the examinations made by the Massachusetts Board of Health, the proportion of trichinous hogs found was 6.3 per cent. Although infection with trichinæ is very rare among our soldiers, only one case having been reported during the thirty-one years 1868 to 1898, this immunity should be regarded as due rather to a national dislike of under-done pork than to the freedom of swine from this parasite.

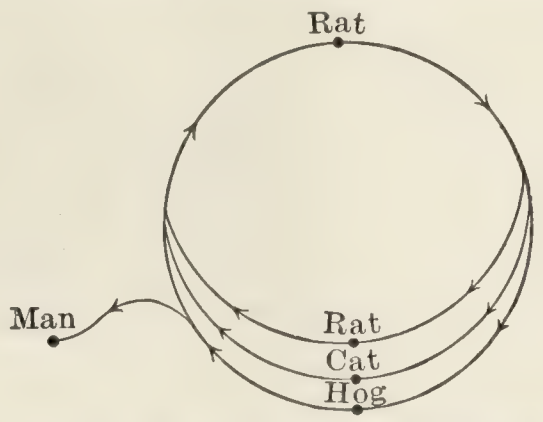


FIG. 76.—Life Cycle and Intermediate Hosts of Trichina spiralis. (After Bollinger.)

Several severe epidemics of trichinosis have occurred in the German army, and the symptoms induced by this parasite are so severe that careful inspection of the pork supplies in this respect is of great importance.

The presence of trichinæ cannot be determined in the living animal unless a bit of muscle be removed from the under part of the tongue and examined microscopically. In human beings affected with trichinosis, the blood has been found to contain a greatly increased proportion of large, coarsely granulated, eosinophile cells; but as yet no application of this test has been made to swine. Within the muscles of animals affected with this parasite may be seen tiny, opaque, ovoid cysts, having a length of about .015 inch and a breadth of .006 inch, within which are coiled very small worms, only to be detected with the microscope. These bodies represent the embryonic stage of the parasite; when swallowed, the enveloping cyst wall is digested and the embryo liberated. The latter develops in the intestinal canal and reaches maturity in five or six days. The mature worm is white and about the thickness of a hair. The female at once begins to procreate, giving off from a thousand to fifteen hundred embryos at a brood; these passing into the system by way of the lymphatics. After penetrating the muscular fibrillæ they become encysted, the cyst wall becoming thickened and finally undergoing calcification; in which condition they appear as opaque, whitish, lens-shaped bodies. Trichinæ are observed in the flesh of hogs, cats and rats; less frequently in certain other animals. The rat and cat are believed frequently to play a part as intermediate hosts in its occurrence in swine.

To the naked eye, pork infected with trichinæ usually presents nothing characteristic. In certain cases in which the cysts have undergone calcification they may appear as white dots, and if very numerous may give rise to a distinct grating sensation under the knife. For the microscopical examination thin strips of muscle should preferably be cut from the tongue, diaphragm, muscles of the jaw and larynx, or the intercostal muscles, since these parts are the ones most liable to harbor the parasite. These strips are pressed firmly between two glass slides and then examined under a magnifying power of forty to sixty diameters. If the meat is very fat it may be treated first with ether or benzine. The muscle may be cleared and the cysts rendered more prominent by immersing the bit of muscle in a solution of weak potassa, one to eight, for a few minutes; but if left in

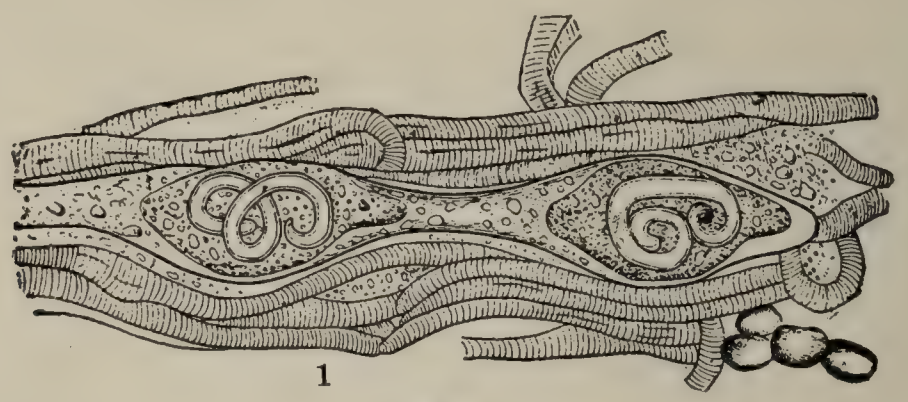


FIG. 74.—1, Trichinæ in muscle; 2, embryo trichinæ; 3, encysted trichinæ; 4, cyst containing seven trichinæ; 5, trichina in fatty tissue; 6, trichina removed from cyst. (After Laveran.)

too long the trichinæ are destroyed by the alkali. Calcified trichinæ may be rendered transparent by the addition of a drop or so of diluted acetic or hydrochloric acid, when the worm is distinctly seen. Trichinæ are not destroyed by the ordinary process of smoking meat; but hot smoking, according to Leuckart, does destroy them. Pickling in strong brine is said by Stiles to kill them in about four months, but neither freezing nor the complete decomposition of the meat destroys their vitality. They are readily killed by exposure for a few minutes to a temperature capable of coagulating albumin (158° F.); but when the interior of a piece of pork still retains the fresh red color of uncooked meat, it may be assumed that a temperature sufficiently high to destroy this parasite has not been attained. It is by no means easy to raise the temperature in the interior of a large ham sufficiently to destroy with certainty the contained trichinæ, and constant boiling for several hours should invariably be required.

It is scarcely necessary to say that where the presence of trichinæ can be positively demonstrated the affected meat should be promptly condemned.

The so-called Psorospermia, or Rainey's capsules, must not be mistaken for trichinæ, nor indeed with care is error possible. These are small, almost transparent bodies, found in the flesh of oxen, sheep and pigs. They are oval or spindle-shaped, or sometimes one end is pointed and the other rounded, or they are kidney-shaped. The investing membrane exhibits delicate markings, caused by a linear arrangement of minute, hair-like fibres which are stated to increase in size as the parasite gets older. They are sometimes pointed, and the appearance under a high power (one thousand diameters) is as if the investment consisted of very delicate, transparent, conical hairs, terminating in a pointed process. The contents of the cysts consist of granular matter, the granules or particles of which, when mature, are oval and adhere together so as to form indistinct divisions of the entire mass. The length varies from one three-hundredth to one-fourth of an inch. They are usually narrow; they lie within the sarcolemma, and appear often not to irritate the muscle. In human beings these bodies are not known to produce any ill effects, but their existence should be remembered in searching for trichinæ.

Bacon.—In the military service the flesh of swine is ordinarily used in the form of bacon or salt pork. The composition of the former, as ordinarily issued to troops, is as follows:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
16.8	9.2	61.8	2,606

For field use no meat can take the place of bacon. It is readily transported, prepared and digested; is appetizing when properly cooked, and possesses a high calorific value in a small bulk. It is much more acceptable than pork, but contains too high a proportion of fats to render its frequent issue desirable in hot climates. For such stations, bacon consisting of almost clear fat should not be issued, but a fair proportion of lean should be required. As a general rule, the further north the station the greater the proportion of fat which may be allowed. Discrimination should be used by the Subsistence Department in this respect. When very fat the loss in cooking is great; the soldier when frying his bacon in his individual mess-tin rarely securing the full benefit of the melted fat. Many soldiers prefer to fry their bacon to a crisp, rejecting the grease—in which case only a relatively small proportion of its nutritive substance is utilized. In general, the weight of the sides determines the proportion of fat, and sides weighing from twenty-five to fifty pounds are preferable.

The wastage of bacon under natural heat is often considerable, amounting at times to as much as twenty or twenty-five per cent. When slop-fed and summer-cured, bacon is said to waste much more rapidly than when corn-fed or winter-cured. Notwithstanding this waste under heat, properly selected bacon should be generally substituted for salt pork at southern posts. Bacon is preferably stored in the crates in which it is

issued. It has been stored in bins, packed with bulk salt in alternate layers, but the salt appears to cause the separation of the fatty portion from the rind. At southern posts, where bacon becomes very soft and liquescent, it is best packed in charcoal, after wrapping in clean cotton cloths.

Poorly cured bacon is soft and watery and will not keep. When cut into, moisture appears in the incision. The only remedy for this condition is a second smoking. When the fat of bacon is yellow and the taste is strong, the meat is rusty or tainted. When the lean shows brownish or black spots it is not good. Bacon from stag hogs or those fed on mash may have a yellowish appearance and still be fit for use.

The Dermestes lardarius or bacon-bug is very destructive to bacon and all other kinds of dried meat. It is a rapid breeder, and a generation may be developed in six weeks. This insect deposits its eggs on bacon or other dried meats; the larvæ being hatched from these and at once beginning their attacks on the flesh. When full-fed they change into the chrysalid state and from that into the beetle; the latter being about one-third of an



FIG. 78.—Dermestes lardarius: *a*, larva; *b*, pupa; *c*, adult beetle—all enlarged.

inch long and of a dusky-brown color, except the upper half of the wing cases, which are of a whitish or ashen color. These insects, when in the larval and chrysalid states, are so concealed in the meat that they cannot be removed from it—but upon attaining the beetle state they may be readily removed and destroyed. Affected portions of bacon should be cut away. Where a commissary store-room is overrun with these insects, the room should be cleared out as far as practicable, and sprayed with benzine or subjected to strong fumes of bisulphide of carbon. The latter method is much recommended, as the disagreeable odor of this substance soon disappears.

Salt Pork.—The chemical composition of salt pork, as issued, is in general as follows:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
16.2	16.2	66.2	2,733

Salt pork is by no means a popular component of the ration. It is rarely used in garrison except when cooked as an adjunct to beans or vegetables, and in the field it is entirely supplanted by bacon. So many and so general were the complaints made, a decade ago, against salt pork as a food for the soldier, particularly from southern stations, that the matter received special consideration in the report of the surgeon general for 1889, and strong evidence was adduced against its further issue to troops. It was shown not to be relished by the men and to be rarely used, and was reported as being "repulsive to taste and digestion." Formerly it formed three-twentieths of the meat ration; and in the department of Texas it was reported by the commanding general that, for the year 1885, one-half the issue of pork was turned back to the commissary and its money value expended for other foods, it thus being utilized merely as a means of exchange. This dislike of pork, however, was not shared by the colored troops, and in a sanitary report from Fort Duncan, Texas, in 1880, it was stated that three colored companies, with an aggregate strength of one hundred and forty-one, saved only three hundred and fifty-seven pounds of pork—and one of these companies made no saving in this respect; while in a company of white troops at the same post, with an average strength of fifty-eight men, no less than three thousand pounds were saved during the same period. In the entire department of Texas it was found that the white troops saved and sold proportionately twice as much pork as did the negro soldiers. It would undoubtedly be of advantage if pork were replaced in the ration by an allowance of cheese, leaving the small amount of pork which might be desired for cooking purposes to be purchased from the commissary as required.

Corn-fed pork is the best quality of pork found in the general market. It can be distinguished from mash, slop or swill-fed pork by its pearly appearance, and by its retaining the dent of the finger on pressure. Mash-fed pork has a blue tinge, is spongy and is elastic to the touch. Winter-killed pork is much better than pork killed in warm weather. If it freezes before thoroughly cured, however, it will spoil when thawed out; as freezing suspends the pickling process. Pork should be subject to frequent inspection. If the meat is a little turned it may at times be saved by rubbing in salt and rebrining. The barrels should be kept on the side, rolled at weekly intervals and carefully protected from the sun. Pork is never safe if there is not a considerable quantity of undissolved salt in the barrel; and the loss of brine by evaporation must be promptly made good. If brine be added it should be of sufficient density to float an egg.

Horse Meat.—The flesh of the horse, though not employed for the subsistence of troops in time of peace, is capable of rendering excellent service during campaign. It was much used by the French during the sieges of Metz and Paris in the Franco-Prussian War, was lately employed during the Anglo-Boer War, and, together with mule meat, has not infrequently been of necessity utilized by our own troops in expeditions against hostile Indians. Horse meat is palatable and wholesome, and where the meat ration is at all insufficient the flesh of animals killed in action should certainly be utilized as food. The flesh of the horse is said to contain about ten per cent. more nitrogen than good beef; a quality which should make it especially valuable in connection with the shortage of food and the

arduous labors incident to hard fighting. Horse meat is now regarded as a staple article of diet among the poorer classes of Europe, Laveran stating that in 1892 no less than twenty thousand horses were slaughtered for food in Paris alone; and in the western part of our own country it is said that several companies are engaged in canning the flesh of the half-wild horses of the plains for European consumption. In view of its common use abroad it has recently been proposed, from motives of economy, to include horse flesh in the meat ration of several foreign armies. Its issue in our own service, however, would never be countenanced except as a measure of urgent necessity.

Horse meat can be detected by the horse having eighteen pairs of ribs, while the ox has but thirteen pairs; the tongue of the horse is smooth at the tip and base of blade, while the tongue of the ox is rough. Ordinarily, however, a fore-quarter with more than the number of ribs possessed by the ox would not be presented; hence the points to be chiefly relied upon are the darker color and coarser fibre of the flesh of the horse, the yellow, oily fat, the greater size of the bones and their oily marrow, the peculiar odor and somewhat unpleasant taste of the fat. The flesh of the horse appears to be less liable to transmit disease than either pork or bacon, since this animal is not liable to trichinosis, is relatively insusceptible to tuberculosis and is not known to contain parasites which can be transmitted to man. The horse is frequently affected with glanders, but the flesh of glandered animals does not appear necessarily to produce injurious effects, if thoroughly cooked, when eaten as food. Viry quotes an instance in which three hundred glandered horses were eaten without injury; and in 1870, during the siege of Paris, large quantities of flesh from horses with farcy and glanders were eaten without producing ill effects. There can be no doubt that glandered flesh, however, if insufficiently cooked, is capable of transmitting this disease to the consumer.

Slaughter-Houses.—In addition to the examination of the animal from which the meat is derived, and of the meat itself, it may frequently devolve upon the sanitary officer to supervise the method of slaughtering and cutting up of the carcass, and insure that all the steps are carried out in a cleanly manner and that the meat is not unnecessarily contaminated by carelessness or filthy surroundings. Slaughter-houses are naturally centres of disease, and the more unsanitary the condition of the premises the more dangerous they become to health. It not infrequently happens that little care is bestowed upon the policing of such an establishment and its vicinity, which, in the nature of things, are befouled with urine, droppings, blood and decomposing offal. This is a matter requiring the constant attention of the supervising officer, and every effort should be made to promote cleanliness and remove unsanitary conditions. Frequently slaughter-houses are located on the banks of streams, which, lower in their course, are sources of water supply; and in many instances the offal is thrown out to be eaten by hogs kept for the purpose, or by rats and prowling dogs. This practice is extremely dangerous, for even if the abattoir be small the number of animals slaughtered therein in the course of a year may be considerable. Among the hogs slaughtered, a certain proportion are sure to be affected with trichinosis, and when the offal of a trichinous hog is fed to swine the latter cannot escape infection with trichinæ. But

this is not all; for rats act as transmitters of trichinæ to hogs, and slaughter-houses are usually overrun with these vermin. Where these feed on the offal of trichinous animals they likewise acquire trichinosis; Stiles finding fifty-five per cent. of rats killed in slaughter-houses, meat shops and packing-houses to be so diseased. The affected rats, after death, are themselves not infrequently eaten by hogs—and further, if the abattoir be burned or abandoned, they scatter in all directions for the purpose of obtaining food and thus greatly increase the chances of the dissemination of the disease among swine kept in the vicinity. Hence the great necessity for keeping down the rats by the use of traps, cats, ferrets and poison.

Tuberculosis is also transmitted by flesh, and swine fed on the offal of tuberculous animals themselves become affected, and may, when slaughtered, give rise to the disease in man. Dogs also are attracted to slaughter-houses; and through eating the discarded organs they infect themselves with several kinds of parasites, among them the echinococcus disease, the thin-neck bladder worm, the gid bladder worm and the tongue worm. The first named parasite is extremely dangerous to man—the latter affect animals. The dog, after eating flesh containing parasites, proves a congenial host for the development of the mature tapeworms, and naturally deposits the eggs, with the excreta, in all directions and under conditions which favor their entrance by the medium of water and herbage into hosts suitable for their development. It is obvious that dogs should be prevented from having access to abattoirs or their animal refuse.

It is needless to enumerate all the diseases which might centre at a slaughter-house; but anthrax, tuberculosis, hog cholera and swine plague may be mentioned. As the yards and buildings will often harbor the specific organisms of these and other diseases, it should be a rule that an animal once admitted to a slaughter-house should not leave it alive. The flesh of diseased animals should be burned, not buried; since in such a case the carcasses may become food for dogs, rats and burrowing animals. Further, on Indian reservations or in the tropics, they may be subsequently disinterred and used as food by the natives.

In construction, slaughter-houses should be solidly built, preferably of brick or stone, and should have cemented floors throughout. They should be well drained and scrupulously maintained in a good sanitary condition. In the transportation of meat the strictest cleanliness of hands and clothing should be required of those in charge of its conveyance from place to place, and of the wrappers, receptacles or vehicles in which it is so conveyed. During transportation to the place of issue the meat should be well exposed to air; under no circumstances should it be wrapped in rubber sheeting, as is sometimes done, but the air should have access to it at all times. When kept in store, without refrigeration, the meat should be hung up in as cool a place as possible, the pieces being not too close to the wall or to each other, well protected from dust, sun and flies, and, if possible, in a free current of air.

PRESERVATION OF MEAT.

The necessities of the military service obviously require that meat should frequently be consumed at considerable distances from the places of production and slaughter; and hence its preservation, by physical and

chemical means, has been an object of constant study on the part of those who have the subsistence of troops at heart. The artificial refrigeration of meat, a process only of comparatively recent development, has done much toward satisfactorily solving this vexed problem. The following methods have been employed for the preservation of meat.

Method of Slaughter.—It has been demonstrated that meat killed in the Jewish manner will keep one or two days longer in summer than meat killed the ordinary way, since the more thoroughly the blood is removed the better the meat keeps. In the Jewish or "kosher" method the animal is hauled up by the hind legs and the throat is rapidly cut without previous stunning; the vessels retain their contractility and convulsions take place, which still further help to squeeze all blood from the body. If the animal is first stunned the bleeding is imperfect and considerable blood is left in the hind-quarters. The objection to this method of killing is the unnecessary cruelty attaching to it. The same result is reached in a new process by which the keeping qualities of the meat are said to be markedly enhanced. In this method, after previous stunning and bleeding, the large blood-vessels are washed out with a weak, sterilized salt solution; the irrigation being continued for some minutes until the escaping fluid is only faintly colored. The animal is hung up by the hind legs during the operation, and the irrigating trocars are plunged into the femoral arteries. Where refrigeration is not available, and it is desired to keep meat several days during warm weather, this method of preservation has much to commend it, being simple of execution and entirely avoiding the use of chemical preservatives.

Refrigerated and Frozen Meat.—The preservation of meat by cold, and its transportation in the chilled or frozen state over long distances to the point of issue, is now a common procedure in the military service. In France, Germany and other countries, military cold-storage establishments, fully provisioned against emergency, are maintained at strategic points from which distribution can be readily accomplished. Viry states that one-fifth of all the cold-storage establishments in Germany are exclusively employed in the military service. In the United States army no need for such establishments has existed, through the comparatively small numbers of the regular army, its dissemination in small garrisons over a wide area, the readiness with which supplies could be obtained by reason of excellent transportation facilities, the existence of large, centrally located packing-houses belonging to private corporations, and finally, the geographical situation of this country, through which invasion by foreign forces is rendered impossible. In the tropical possessions, however, no such conditions prevail, and in Cuba, Porto Rico and the Philippines the establishment of cold-storage facilities has been found essential. In the Philippines the troops were at first supplied direct from the ships bringing meat from the United States and Australia, but recently a refrigerating plant has been established at Manila, having a capacity of five thousand beeves, eight thousand sheep and other perishable articles in like proportion.

As delivered to troops, refrigerated beef is almost invariably of excellent quality and in prime condition. Little difficulty has been experienced in preserving the meat until required for use, although in several instances in our service the refrigerating apparatus on board transports has broken

down during the voyage and all perishable articles lost in consequence. Refrigerated beef, as shipped to troops in the tropics, is far superior to native grown meat, which is usually deficient in fat and is tough and stringy from the fact that it must be used a few hours after killing to prevent spoiling, even though rigor mortis be still present. Meat should be refrigerated rather than frozen if it is to be issued at no great distance from the point of refrigeration. Where transportation over considerable distances is required for the supply of troops, actual congelation becomes advisable in the prevention of putrefaction. As an additional precaution against contamination and spoiling, the quarters should be sewed in clean, sterilized cotton cloths before shipping. Refrigerated beef differs slightly in appearance from fresh, having a dead color and lacking the lustre characteristic of good fresh meat. The lean is somewhat pale in hue and more of a brick-red color than the bright, rich red of recently killed beef. The fat is pale pink instead of white, due to the juice of the lean soaking into the fat. A general pinkish tinge extends over the whole of the carcass and the gristle of the joints is pinkish instead of bluish in color. The shanks are bruised and discolored owing to the method of hanging up the quarters. Sometimes the shanks are much lacerated, and such injured portions, besides being objectionable in appearance, readily become tainted. The carcass itself is cold to the touch, stiff and moist. On removing the cloth in which the quarter is wrapped for transportation a slightly unpleasant odor is sometimes discernible; but care should be taken not to reject such meat without further examination, since the smell may be merely a surface one caused by the cloth. When this is removed the quarters should invariably be cut into, when if any taint exists it will be readily detected.

Meat in the frozen state is readily recognized. In the thawed or semi-thawed condition the outside has a wet, water-logged appearance, and there is considerable oozing and dripping of a watery liquid from the carcass. Should it have been kept so long a time as to have lost its outward moisture it can be recognized by a generally dull, dirty appearance, and on a fresh section being made the watery condition is at once apparent. This dripping and infiltration is due to the rupture of the cells by freezing and the subsequent escape of their liquid contents, to the no slight deterioration of quality. The flesh has a uniform pink appearance, owing to diffusion of the coloring matter in the blood. The fat, however, is unstained and is of a tallowy white color. The outside of the meat is dull and lacking in lustre.

It is said that in the Philippines frozen quarters of beef have been transported to troops on the firing line fifty miles from the cold-storage establishment, and have been kept free from taint for as much as three days without further refrigeration, even in a tropical temperature.

Frozen beef is not accepted in the British army, although frozen mutton is regarded as satisfactory. The reason for this discrimination is that the carcasses of sheep are frozen whole, while beef is cut into a considerable number of parts, and on thawing the loss of nutritive matter from the flowing of liquid from the cut surfaces is much greater. Mutton being naturally drier than beef it is said to suffer less deterioration in the freezing process. The committee appointed to investigate the dietary of the

British soldier recommended that when frozen meat is issued an extra allowance of ten per cent should be added "on account of the waste that occurs in the process of cooking it." Since frozen meat is now much used in our service it would seem as if this matter deserved attention.

Frozen meat, after thawing, undergoes decomposition much more readily than refrigerated meat, through its infiltration with serous fluid. To the mechanical disorganization of the tissues from rupture of the muscle cells is thus added the diffusion through the meat of a fluid which furnishes an admirable culture medium for the development of the microorganisms of putrefaction. In the inspection of frozen or refrigerated meat it should be cut through in the thickest part, since when the meat is frozen while still warm, the outside forms a hard protective casing behind which putrefaction may be possible. It has recently been stated in a sanitary journal that meat long kept in cold storage undergoes a deterioration of intangible character. Such meat is said ultimately to lose in flavor and be poorly assimilated. It is also stated that those who eat meat long preserved in cold storage are particularly prone to diarrhœa. The moral of this is to avoid keeping meat in cold storage any great length of time, and to make contracts for small but frequent consignments of the freshly killed article.

The apparatus for the production and maintenance of artificial refrigeration, at permanent posts, is discussed in a subsequent section. To insure the better keeping of meat in the field, an excavated cellar may be made in connection with the camp kitchen, roofed with logs, brush, leaves and a heavy covering of earth, and having a passageway communicating with a small tent. Excellent surface drainage must be provided for the removal of storm water; while, if the ground water be high, subsoil drainage by trenches somewhat deeper than the cellar, and carried to a lower level, should be instituted. These trenches should be partially filled with large stones, loosely placed; or poles be laid horizontally to carry off the water. Where ice is available in the field, excellent ice chests may be made of packing boxes sunk in the ground one inside the other, and having holes bored in the bottom to allow the escape of water. A tight lid is provided for each box, and the whole shielded from the sun. In garrison, a more elaborate commercial form of refrigerator will usually be employed. These should be well lined with zinc throughout. Some refrigerators now supplied by the Quartermaster's Department are wooden throughout, absorb odors and organic matter and are incapable of proper cleansing. The sanitary condition of such refrigerators soon becomes very bad, and the slight additional cost of better models should not be allowed to stand in the way of their issue.

Preservation by Heat.—Directly opposed to the method of refrigeration is one consisting in exposing the meat to a high temperature for a few minutes; thus destroying the bacteria and coagulating the albumen in the surface layers and hermetically sealing the interior. This process is obviously not applicable except on a small scale, and is of value for limited periods only. In hot weather, in the absence of ice, the use of this method of preservation will frequently be temporarily of advantage to troops in the field.

Desiccation.—Drying or "jerking" meat in the open air is a common

method of preservation among the Indians and frontiersmen of the west, where the dry air prevents putrefaction. "Jerked" meat has not been infrequently employed by United States troops during campaign against hostile Indians, the flesh of the game killed while on compaign being often preserved for future use in this manner. It appears to have given satisfaction, and is very palatable when made up in soup or stews. It is obvious that this method of preparation is possible only under suitable atmospheric conditions. This process is artificially imitated in the dried beef of commerce; but the latter is also treated with salt and is too strongly impregnated with saline material to be of utility for the military service. Pemmican—dried meat pounded to a powder and mixed with fat, sugar and raisins—is an excellent food, formerly much used in the far Northwest. It was employed in the military exploring expedition in the Arctic led by Greeley, and has also been used by military exploring expeditions in Alaska. Its composition, concentration, keeping qualities and portability give it a high place among the preserved meats.

Smoking.—This is a method of preservation which is usually employed —as in the preparation of bacon—in connection with salting and drying. The best woods for smoking are hickory and rock maple, the preservation being due to the absorption of pyroligneous acid and creosote from the smoke generated in the slow combustion of the wood fuel.

Canning.—Next to refrigeration, the canning of meat is pre-eminently the best method of its preservation; but it may be laid down as a general rule that preserved meat should be regarded purely as a variety of diet and used rarely. For the military service, the compactness, portability and keeping qualities of canned meat render it of especial value.

Canned fresh beef, known as "roast" beef, has long been used successfully as a component of the United States army travel ration, but was subjected to much unfavorable criticism when used by troops in Cuba and Porto Rico during the war with Spain. This criticism, however, was due not so much to the undesirable character of the food itself as to the fact that it was, from force of circumstances, usually eaten direct from the can, and its issue was continued for so long a period that the very monotony of the diet produced a marked repugnance to this meat on the part of troops. Where issued only occasionally, and where proper facilities for making it into hash or stews are furnished, canned meat may be regarded as an acceptable article of food for troops. It is much used and liked in foreign armies—notably the French army—in which stewing is the usual method of preparing the meat ration. It is quite unsuited for use when eaten direct from the tin, since the meat is comparatively tasteless and stringy and the fat is collected in an unappetizing cake at the top of the can. Canned beef contains no bone—a great saving to the soldier—and much of the water and fat is removed by the processes to which it is subjected. Its fuel value is fully equal to fresh beef, pound for pound, while the proportion of nitrogenous matter is much greater. It should, therefore, prove satisfactory—temporarily at least—for nutritive purposes in the field; for which use its keeping qualities, and the fact that it may in emergency be eaten without cooking, render it particularly applicable. The influence of canning on the composition of beef is shown by the following analysis, hitherto unpublished, made by Bigelow for the Department of Agriculture,

on three hundred and fifty-eight pounds of fresh beef which was converted under his observation into two hundred and thirty-five pounds of canned beef.

	Fresh beef, weight and composition in Pounds Avoirdupois.	Extracted by boiling. Pounds Avoirdupois.	Added in canning. Pounds Avoirdupois.	Calculated composition of canned meat, Pounds Avoirdupois.	Composition of resulting canned meat, as determined by analysis, Pounds Avoirdupois.
Water	254.8	122.1	14.1	....	146.8
Proteids, total	59.3	0.1	.1	59.3	58.5
" coagulated.	49.7	....	....	54.6	52.3
" globulins	4.9				
Proteoses, Peptones, Gelatin	4.7	.1	1.6	4.6	6.2
Meat bases	3.9	.7	....	3.1	2.7
Fat	35.4	12.2	....	....	23.2
Ash	3.4	.7	.2	2.9	2.1
Sodium chloride	.1	.1	.2	....	.4
Undetermined	1.2	....	....	....	1.7
Totals	358.0	....	....	....	235.0

The chemical composition of canned roast and boiled beef, as given by Atwater and Bryant, is as follows:

	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Canned roast beef	58.9	25.9	14.8	1,105
Canned boiled beef	51.8	25.5	22.5	1,425

It is readily seen from the above tables that the popular statement that the "good" is all removed from canned beef is quite without foundation in fact; the latter contains, weight for weight, a much greater amount of nitrogenous material, while the proportion of fat in the fresh and canned meat is almost exactly the same—although there is an actual loss, in this respect, of about one-third. It is true that a certain proportion of the extractives, which give flavor to the meat, are unavoidably removed in boiling, but of these, according to analyses made by the Department of Agriculture, not more than one-sixth to one-third, varying with the special method of processing, is extracted in canning. These substances, moreover, have no positive nutritive value but may be regarded merely as stimulants. Of the total proteid in canned beef, it is stated by Notter and Firth that not more than ten per cent. was found by them to be indigestible. The meat used for canning is ordinarily of good quality, although the less valuable portions of the animal, as the chuck and rib trimmings, are commonly utilized for this purpose. It is claimed, however, that partially spoiled meat is sometimes used for this purpose by unscrupulous dealers. In the inquiry after the war with Spain, one officer testified to finding dead maggots in a can on opening it.

On its preparation, the beef is first placed in water and maintained at a temperature of 95° C. until well cooked. It is then removed, trimmed

and placed in cans, a little gelatin being added to bind the meat together. The cans are then sealed and either submerged in boiling brine or placed in super-heated steam at 125° C. The contained steam is allowed to escape through a puncture made in the cap of the can, which is immediately afterward closed with solder.

The meat being sealed up while hot, any portion of the enclosed space is a partial vacuum; consequently a good tin of meat will almost invariably present a concave appearance on its external surfaces through the pressure of the atmosphere. When a tin is bulged it is sure to be bad—unless it be frozen—and should be rejected. The bulging is due to the generation of gas in the process of decomposition of the meat inside. The ends of such cans, if pressed, give out a rattling sound and resume their convex shape on removal of the pressure. Freezing causes a bulging of the ends of cans without injuring their contents. The ends, after the contents of the can have been thawed, return to their former shape; but a number of freezings and thawings may so change the contents of the tin that the ends will not, on removal of pressure, remain in their original shape.

The process of canning articles of food involves the making and soldering up of two punctured holes in the top of each can, and these have no bad significance. The presence, however, of three such holes is an evidence that the can had been imperfectly processed, and that to remedy this defect it was re-heated, the gas of fermentation allowed to escape, and the hole punctured for this purpose again sealed up. The contents of re-heated cans are more likely to be of inferior quality, or subsequently to undergo putrefactive changes, than cans properly processed in the first instance. Owing to the objections to re-heated cans, the packers are careful to make the third puncture as inconspicuous as possible; and frequently endeavor to conceal it entirely by making it on the side of the can, near the top, and pasting the label over it. By running the finger abound the rim of a can it is easily determined whether a third hole has been made, by the presence or absence of a lump of solder. Sometimes newly packed cans are so much swollen that re-heating is not sufficient. In such cases the cans are opened, the contents sorted over and the sound parts packed into cans, which are then subjected to the same process as in the original canning. Re-processed cans of this character have the same appearance as regularly packed cans, and their defective quality can be determined only by opening and examining their contents, which will present an overcooked appearance. First-class canned goods have both the name of the factory and that of the wholesale house through which they are sold upon their labels. Doubtful goods have a fictitious factory name, and no dealer's name. These are easily avoided in peace—but under the pressure of war, supplies of this character are apt to deteriorate and must be critically watched.

Canned meats, when properly stored, should theoretically retain their good qualities indefinitely in any climate. A certain gradual deterioration appears, however, to occur, and Morache states that in cans of meat a change, similar to the formation of adipocere, sometimes occurs. Viry states that putrefactive changes may take place without the formation of any gases. He recommends that canned meat having a fishy or putrefac-

tive odor, in which the fat is liquefied or has lost its transparency, or when the meat is soft or discolored, should be rejected. He states that these conditions may occur in canned meats presenting no outward signs of bad quality, and remarks that a considerable number of cases of illness among the French troops has demonstrated the danger of using meat of this character.

Coustan mentions ten severe outbreaks of ptomaine poisoning, occurring from the use of canned meats, as having been noted in the French army. Barker has recently observed severe poisoning in twenty-four persons following the use of canned beef. He states that this meat presented no unusual appearance other than that it was less firm than is ordinarily the case, and the jelly was slightly oily. The meat had no odor, and its taste was not unpleasant except to a single individual of those who partook of it. Meat contained in pierced tins will, of course, putrefy very quickly, and therefore all cans showing holes made by nails, rust, crushing or other means should be rejected. In an inspection recently made in Cuba, many thousand cans of meat, which had been carried in the holds of transports and had come into contact with salt water, were found to have rusted through and their contents undergone decomposition. It is important that cans of meat should not be opened except as required for immediate use, since canned meat appears to undergo putrefactive changes more quickly than fresh meat.

The quality of canned roast or boiled beef is determined by its appearance, which should be bright, lively and well colored; by its flavor, which should be pleasant, and by its freedom from gristle, sinew and fascia. A due proportion of fat should be present. This is usually collected with the gelatin at the top of the can. Packers endeavor to prevent the solidification of this fat in cakes, during the process of cooling, by frequent turning of the cans—but their efforts are only partially successful. Canned beef contains ordinarily from fifty to sixty per cent. of moisture. The transportation of this amount of innutritious matter in the field ration is certainly undesirable, but it is admitted by the canners that the meat is stringy, uninviting and flavorless unless this proportion of water be allowed to remain.

It is not disputed that canned food frequently contains tin, which has been dissolved from the tin plate by the action of acids or other constituents of the food, or which have been introduced through the careless use of stannous chloride, a constituent of some of the soldering fluids used in sealing cans. But the quantity of tin is usually very small, varying from a few hundredths of a grain to one grain per pound—rarely approaching, however, the higher figure. These amounts are not likely to give rise to acute poisoning. Usually canned fruits and vegetables, from their contained acids, are more liable to dissolve tin than is meat so preserved. Blyth states that he found in some samples of canned fruit as much as 14.3 grains of stannous chloride per pound, and that the average amount of all examined was 5.2 grains per pound. In some cases the juice had a metallic taste. With such quantities of tin, in a form easily absorbed into the system, the possibility of acute poisoning must be admitted. But tin poisoning, from the use of canned foods, is not greatly to be feared. A quantity of tin salt sufficient to cause acute poisoning would probably be

recognized by the taste, and food so contaminated would be rejected as unpalatable. Used in the manner in which canned food should be employed in the military service, the possibility of chronic tin poisoning should also not exist. In speaking of a number of cans of beef examined by him for the Department of Agriculture, Wiley remarks as follows:

"On opening the cans it was found in many instances that the tins on the inside were discolored, and it was first considered that actual erosion had taken place. A careful microscopic examination of the surface, however, showed that this assumption was an error. In no case was the surface of the tin found to be eroded, and the discolorations were due doubtless to the natural effect of the meats upon the tin surface." In general, the tin used in making cans should be of the best quality and the solder should be carefully applied to the outside of the cans only, so as to prevent it from coming into contact with the contents.

It is important that animals to be used for canning purposes should be inspected on the hoof, since if the animal is sick and the flesh contains bacteria or toxines, the heat of processing may not destroy the toxines or spores of the bacteria even though the micro-organisms themselves do not survive.

Canned corned beef is prepared in almost exactly the same manner as canned roast or boiled meat, the flesh having previously lain in pickle for fifteen to twenty days. It is the usual meat component of the travel ration, for which purpose it has given entire satisfaction. Its percentage chemical composition is as follows:

	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Canned corned beef	51.8	26.3	18.7	1,280

Canned corned beef is very salty and soon becomes distasteful to troops. Its employment, except for very brief periods only, should be condemned. Meat is sometimes preserved in tin cases by partly excluding air and destroying the oxygen of the remaining part with sodium sulphide. In another process the air is removed from the packed cans and nitrogen, with a little sulphur dioxide, substituted.

Salting.—Corning is treating raw beef or pork to a pickle, usually composed in the proportion of two gallons of water, four pounds of salt, one and one-half pounds of brown sugar, one and one-half ounces of saltpetre and one-half ounce of saleratus. The meat, cut into pieces of about eight pounds each, is put in the brine under a weight. After an immersion of eight or ten days it is ready for use. If the meat is pickled directly from the block, the bloody brine should be renewed every three or four days until all the blood has soaked out. In corned beef the extractives are in great part removed by the brine, while the albumen is hardened and the meat thus rendered tough and insipid. The process of curing appears somewhat to impair digestibility and the meat is much too salty for continued use. In the expedition to Porto Rico, when a deficiency of transportation rendered it necessary to use canned corned beef for a number of days, the men were said to have suffered greatly from thirst and to have

been affected with a condition of the mouth similar to that resulting from mild mercurial salivation.

Salt beef is good only when new; after a year it becomes dry and tough, especially if made of fresh beef of inferior quality. The determination of the quality of corned meat is by no means easy and the test of cooking must often be employed. When the salting is badly done signs of putrefaction can often be detected. The meat is paler than it should be, is often slightly greenish in appearance and may have a peculiar odor. If the meat has become tainted before brining, no salting will remove its softness and it may present the odor of putrefaction. If the meat is old, its hardness, toughness and shrivelling will be noted. The use of inferior portions for salting can be determined by inspection of the meat after removal from the brine. It should be remembered that brine is sometimes poisonous. This occurs in cases in which the brine has been used several times; a large quantity of animal substance passes into it and appears to decompose. The special poisonous agent has not been isolated, but probably is a ptomaine. Meat from a pig slaughtered on account of sickness, which had been pickled in strong brine for four days and smoked for three more, was found by Glücksmann to have induced fatal poisoning. Proteus vulgaris was found in the meat and stomach contents, and when injected into animals proved very virulent. The following is the average chemical composition of corned beef:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
49.2	14.3	23.8	1,271

The subject of salt pork has already been discussed.

Chemical Preservatives.—Of these, borax and boric acid are now almost generally employed for the preservation of fresh, raw meat, since they are effective and cheap as well as odorless and their taste is easily lost or disguised when mixed with food. Boric acid is usually preferred by butchers to borax, as the latter is considered to bleach the meat. Boric acid enters largely into the secret powders used for meat preservation, the accessory preservatives being variously salt, saltpetre, sodium sulphite and other substances. Ordinarily the surface of the meat is lightly dusted over with the boric acid, from ten to fifteen grains per pound being usually employed. In the preservation of sausage meat it is said that four ounces are generally used to each one hundred pounds of meat. When large joints are to be treated, it is customary to cut the meat into comparatively small pieces before applying the boric acid, since internal putrefaction frequently occurs in very large pieces of meat and extends from the bone outward. The meat treated with these substances remains in a fresh state for double the usual time and retains its normal qualities and nutritive value.

For the sanitarian the question of chief importance has reference to the possible effects of the continued or frequent use of these preservatives upon the health of consumers. In general, it cannot be said that the influence of borax or boric acid, in this respect, is unfavorable when taken in mod-

erate quantities. Chittenden found no interference with the processes of digestion following the use of borax, and De Cyon observed no disturbance of the general nutrition of dogs when as much as 12 gm. of this substance, added to meat, was used daily—this being ten times the amount which would ordinarily be taken in on preserved meat by human beings. The same writer found that when borax was given in sufficient quantity to produce any effect its action was similar to that of common salt, tending to increase proteid decomposition. Boric acid, in doses up to 3 gm. per day, appears to be without influence upon either proteid metabolism or the general processes of nutrition. Many general statements have been made in condemnation of borax and boric acid preservatives, especially during the recent war with Spain. It is noteworthy, however, that these statements were purely matters of opinion and were not founded on personal observation of any ill effects directly traceable to the use of these substances, and it may probably be accepted that, in the quantities in which they might be taken into the system with food preserved by their agency, they exert no harmful influence upon the organism. This lack of toxicity, however, does not necessarily render the use of the borax compounds desirable for the military service; and this is particularly the case since in artificial refrigeration there is available a far more preferable method of preserving fresh meat, and one which is not open to criticism through the use of chemical substances.

The determination of borax or boric acid in meat is extremely simple, requiring no special apparatus for its accomplishment. A portion of the suspected meat is cut up, boiled in a small amount of water and the latter filtered. A small amount of hydrochloric acid is then added to the filtrate, the best proportion being about one part of strong acid to fifteen parts of the solution. A greater amount of the acid interferes with the reaction. A strip of turmeric paper is then dipped in the acidified solution and allowed to dry, becoming a bright cherry red. After the paper is dried a drop of ammonium or sodium hydrate is added; when, if boric acid be present, the color of the wet paper changes to dark green; or if boric acid be present in large quantity, to a dull black. If no boric acid be present the addition of the alkali produces a light brown tint, but the play of colors—cherry red to green—is characteristic of boric acid.

The use of salicylic acid forms the basis of several methods of preservation; this substance having a marked effect in restraining putrefactive processes. A method successfully employed in the Italian army, as far as the preservation of meat was concerned, consisted in covering fresh meat with a coating of salicylated grease, the whole then being packed in kegs or barrels. Fresh meat so treated was found capable of being preserved about two months without apparent alteration. The salicylated grease was readily removed and was used over again for a number of times. It is understood that this method was not long used.

Salicylic acid is a drug possessed of marked caustic properties when used in strength, and is capable of inducing severe toxic symptoms if taken continuously or in considerable doses. Its use for the preservation of meat intended for troops is unjustifiable. The presence of salicylic acid or the salicylates in suspected meat is readily determined by washing the surface of the meat with water, and adding a few drops of tincture of the chloride

of iron to a test-tubeful of the washings. If salicylic acid or the salicylates be present a deep purple color is developed, varying in intensity with the amount of these substances. This test is delicate enough to determine the presence of one part in the million of the solution.

A process which has been considerably employed in the past for the preservation of meat consists in its exposure, for a number of hours, to the fumes of sulphur dioxide. This process is uncertain in its results. It is believed not to interfere with the digestibility of meat; but when thoroughly carried out the latter acquires a somewhat bitter taste and a sour, putrid odor. This method is now largely abandoned. It is said that a much-criticised quarter of meat carried on a transport to Santiago, during the war with Spain, for trial as to its keeping qualities, had been treated with sulphur dioxide.

Formaldehyde has quite recently been adopted as a food preservative and is now much used—though more especially to add to the keeping qualities of milk than of meat. In the proportion of one to fifty thousand, as has been shown by Rideal and Fullerton, formaldehyde, employed in watery solution, is an effective preservative of milk for twenty-four hours. In this strength, even during extended periods of use, this substance appears to have no injurious effect upon the consumer.

Meat has been preserved by formaldehyde by spraying, or wrapping it in cloths saturated with a solution of no great strength. When preserved in this manner meat will remain free from taint for a number of days. Formaldehyde, however, combines with albuminous material to form a new compound, practically insoluble and highly indigestible. When permitted to come in contact with meat it thus forms a protective surface coating, which, besides possessing directly antiseptic and germicidal properties, mechanically hinders invasion by the bacteria of putrefaction. Meat treated in this way, however, frequently acquires a disagreeable odor, and the appearance of its outer layers is much changed. In the quantity in which formaldehyde could be taken in by the individual with meat preserved by this agent, it may fairly be presumed that no directly toxic effects might be expected. Interference with the digestive processes might fairly be anticipated, unless the outer layers of the meat were cut away and rejected. It may be concluded that for the military service the preservation of meat by formaldehyde is quite inadvisable, and from the chemical changes produced would readily be recognized. Leys states that formaldehyde may be detected by adding together 25 c.c. of the suspected fluid, 10 c.c. of a colorless solution of phloroglucin (1 gm. in 1 liter) and from 5 to 10 c.c. of a weak potash solution, shaking in a test tube. If formaldehyde is present a red color is produced, which disappears after a few minutes.

Other Methods.—Efforts have been made to preserve meat by variously coating it with fat, glucose, gelatin and glycerin. The application of charcoal or sugar to the exterior of meat is said by Woodhull to increase greatly its keeping qualities, and the same writer suggests the rubbing of meat with black gunpowder for the same purpose. It is obvious that such methods of preservation can have no practical value for the military service.

GENERAL PRINCIPLES INVOLVED IN THE COOKING OF MEAT.

By cooking, meat is rendered more pleasing to the eye, acceptable to the palate and digestible by the stomach. Before cooking, meat is tough and stringy, but when cooked the muscular fibres are given firmness from the coagulation of their albumen, and the connective tissue which binds the fibres together is softened into a gelatinous condition especially favorable to the action of the digestive juices. If meat is so tough as to resist the softening action of cooking, it may be made tender, before putting on the fire, by macerating in weak vinegar or cutting into thin slices and pounding across the cut ends until the fibres are broken. From a sanitary standpoint, the cooking of flesh has a special value, since, when properly performed, it destroys all parasites or disease germs existing in it. Meat is commonly cooked by boiling, stewing, roasting or baking, broiling and frying.

Boiling.—In the military service, boiling is a much abused method of cooking. The object of boiling is ordinarily not to extract the constituents from meat, but rather to retain its flavor and nutriment. Hence the piece to be cooked should be large—about five pounds—and should be plunged at once into boiling water, to coagulate the albumen of the outer layers and thus retain the juices. If this is not done, much of the nutritive substance passes into the fluid. The actual period of boiling should not last longer than a few minutes; the temperature should then be lowered and the cooking conducted at a heat at about 160° to 180° F. This is the true cooking point of meat, since above this point the albuminous material becomes completely solidified and, from its hardness, indigestible. Overheating is therefore to be avoided—and the slower the cooking the better the result. Usually meat is boiled fifteen minutes for each pound of its weight. Rapid boiling is to be avoided; additional heat is not generated by furious boiling, and much of the volatile principles escape when steam is rapidly generated. The use of the kitchen thermometer by inexperienced cooks is much to be desired in both boiling and stewing. As ordinarily prepared, boiled meat is somewhat tasteless and comparatively less digestible. The flavor of meat depends upon the extractives present, and these are liable to be removed to considerable extent by this method of cooking. After prolonged boiling the muscular fibres approach the condition of gelatin, a substance possessing but slight nutritive value. Vallin found that after four hours of boiling the internal temperature of a joint of beef attained 90° to 100° C. While this temperature destroys organic life it does not destroy the harmful qualities of ptomaines.

Stewing.—This, when properly conducted, is an admirable way of preparing meat. It is much used in foreign armies but has never become popular in our own service. In stewing, small pieces of the meat should be placed in a little water and the whole maintained at a temperature of 140° to 145° F. for several hours. Very high temperatures, which coagulate and toughen the albumen, defeat the object of stewing, in which the effort is made to dissolve out as large a proportion as possible of the juices of the meat. When stewing is employed the accompanying liquid should be served with the meat; the two dishes combining all the nutritive

principles to be found in roast or boiled meat and at the same time presenting them in a form very easy of digestion and acceptable to the palate. For stewing meat the ordinary water-bath, made on a larger scale, is an excellent cooking apparatus and deserves a place in all company kitchens. In its absence a satisfactory substitute may be improvised. That very high temperatures are quite unnecessary for stewing is shown by the successful results given by the use of the Norwegian stove, to which reference is made in another section.

When it is desired to extract all the goodness of meat to form a soup, the meat should be finely cut up and placed in cold water. After it has soaked for a while, heat should be applied slowly. If a broth is to be made, the heat, though constantly applied, is not allowed to reach boiling for some time, much of the albumen being thus extracted before coagulation has taken place; most of the natural juices having passed into the broth, the meat is left tasteless but still not without some nutritive value. In the making of soup the same procedure is adopted, but simmering is continued longer, as is also the boiling; more of the gelatin being extracted and little of the meat being left except as innutritious and tasteless fibre. The difference between a broth and a soup is, therefore, merely one of degree.

Roasting.—By roasting is properly to be understood that process by which joints or large pieces of meat are cooked by the direct heat of a fire, without interposition of utensils and generally in the open air. This method is at present rarely employed except by individual soldiers in the field, baking being substituted for it. When properly carried out the results are excellent, but in practice this is infrequently the case.

Broiling.—This is the same in principle as roasting, but the scorching of the surface is greater, owing to the larger surface exposed to the heat. The pieces also are smaller and are usually cut in slices. In broiling the article should be turned frequently so as to have it cooked evenly. It is better to broil before a fire than over it, since in the latter case the fat and juices fall into the flames and tend to give a smoky flavor by their ignition. Broiling is rarely used in our service. In the field it occasionally happens that soldiers toast their meat ration before the fire, but such meat is apt to be scorched or imperfectly cooked and the result is usually unsatisfactory.

Baking.—Baking, miscalled roasting, is usually employed in cooking the beef and mutton components of the ration. The temperature of the oven is best maintained at about 400° F. This may be determined by the thermometer; but ordinarily the naked hand and arm are thrust into the oven, and if it can be held there for fifteen seconds the temperature is about right. Experienced cooks are able to make accurate estimations of temperature by this method. Owing to the limited ventilation of the oven the volatile principles are largely retained in the meat. Meat is more savory when roasted than when boiled or stewed, the juices being retained by the protective coating of albumen formed by the high temperature. In all roasting processes, to hasten the course and prevent burning of the superficial parts, the joint should be basted or kept constantly enveloped in a coating of hot melted fat; this, while assisting in the communication of heat, preventing undue evaporation of the juices. In general, about two

and one-half hours are required to cook a ten-pound roast. It should be appreciated that the temperature in the centre of a roast of beef of moderate size remains much below the temperature of boiling, albumen being readily coagulated at a far lower temperature. Vallin found that the central temperature of a large roast frequently did not reach 55° C., even when the temperature of the periphery stood at 120° to 130° C. It is thus apparent that roast meat may be dangerous in spite of cooking as commonly performed.

Frying.—This, generally speaking, is a bad way of cooking. In the field it is probably the most convenient way of preparing the meat ration; and under such circumstances the stimulation of the digestive functions, through hard exercise in the open air, undoubtedly does much to diminish its harmful effects. Where much grease is used, and this is raised to a high temperature (400° F.) before the meat is added, but little fat is absorbed by the latter, since the great heat at once creates a protective coating of coagulated albumen on the outside of the meat. If, however, the fat is not hot enough or is chilled by dropping too much in it at one time, the meat will absorb it and suffer marked deterioration in digestibility and flavor. The latter method is unfortunately the only one ordinarily available to the soldier on campaign. When heated slowly, fat undergoes decomposition into glycerin and fatty acids—the latter materially retarding digestion. When little jets of smoke issue from the melted fat, a suitable temperature for frying has been attained. In garrison, fried foods should always be drained a few moments in a sieve or colander to remove excess of grease.

FISH.

Fresh Fish.—The place of fish in the diet, if judged by its composition, is the same as that of meat; it being supplementary to the vegetable foods, most of which are deficient in protein—the chief nutrient in fish. Fresh fish, when obtainable, makes a useful variation in the diet, but should not be too frequently issued. Troops soon tire of it; besides which its flesh contains so much water, and the wastage incident to its preparation for the table is so great, that the ration of fresh fish, from a nutritive standpoint, is far inferior to the ration of fresh meat. Ordinarily, when dressed for cooking, the entrails, head and fins—and, less frequently, the bones—are removed. This entails a considerable loss in weight as well as of nutritive material. It has been assumed, as a result of numerous investigations, that in dressing fish the following percentages are lost: Large-mouthed black bass, sea bass, cisco, kingfish, mullet, white perch, pickerel, pike, tomcod, weakfish and whitefish, each 17.5 per cent.; small-mouthed black bass, eel, Spanish mackerel, porgy and turbot, each 13.5 per cent.; butterfish, 12.5 per cent.; shad, 11 per cent.; brook trout, 16.5 per cent. More recent figures for loss in weight in dressing are as follows: Bullhead, 50 per cent.; buffalo fish and lake sturgeon, 40 per cent.; carp and sucker, 35 per cent.; fresh-water sheepshead, 23 per cent.; grass pike, black bass, white bass, yellow perch and salmon, 15 per cent.; eels, 10 per cent.

Fish is less satisfying and not so stimulating as the flesh of animals. Contrary to accepted ideas, experiments indicate that fish is less quickly

digested than beef, being about equal to lamb in this respect. However, the difference in digestibility of fish and meat is not very great, and before sweeping deductions are made the thoroughness as well as rapidity with which fish is digested should also be taken into account. A number of experiments have been made on man with reference to the completeness with which fish is digested, and these show that fish and lean beef are ultimately about equally digested. Langworthy states that about ninety-five per cent. of the total dry matter, ninety-seven per cent. of protein and over ninety per cent. of the fat are utilized in the human organism. In general, the digestibility and flavor of fish depend upon the proportion of fat it contains. This varies largely with the species; but white-fleshed fish have little fat while those with darker meat are rich in this substance. Salmon has considerable fat and approaches beef in composition.

The preference for fresh-water or salt-water fish is a matter of individual taste. Both are wholesome. The market value of fish is affected by various conditions, among which are the locality from which they come, the season in which they are taken and the food on which they have grown. In general, it may be said that those from clear, cold or deep water are preferable to those from shallow or warm water, while fish taken in waters with a rocky or sandy bottom are preferable to those from water with a muddy bottom. Some fish, for instance shad, are at their best during the spawning season, while others should not be eaten during this period. Those fish which feed on small crustacea and other forms of animal and vegetable life are preferable to those living upon sewage and other matter which may contaminate the waters. The mode of capture of fish affects their value as food. Those caught by the gills and allowed to die in the water by slow degrees, as is the case where gill nets are used, undergo decomposition very readily and are inferior for food. Fish are often landed alive and allowed to die slowly. This custom is not only inhumane but lessens the value of the fish. It has been found that such as are killed immediately after catching remain firm and bear shipment better than those allowed to die slowly. The quality of the fish is often injured by improper handling before placing on the market.

The majority of fishes are infested with different kinds of parasitic worms. The only one known with any certainty, however, to be conveyed to man is the Bothriocephalus latus. The encysted stage of this worm is passed in either the pike or turbot. Fish, particularly decomposed and some preserved fish, contain various kinds of bacteria which are often of a pathogenic nature. The flesh of apparently healthy fish may produce poisonous symptoms. There is no evidence that such fish are diseased and the flesh may not appear to be decomposed; it at times produces, however, violent symptoms of two kinds—gastro-intestinal irritation and severe ataxic nervous symptoms, with great depression and algidity. The herring, flatfish and others have at times been known to cause these effects. Mackerel also has produced poisonous symptoms, probably through rapid decomposition—for when such fish are cooked immediately after being caught they do not appear to produce any bad effect. The formation of ptomaines quite generally, although not always, accompanies putrefaction. Fish which have been frozen and, after thawing, kept for a time before being cooked are especially likely to contain injurious ptomaines.

In examining fish the inspector should satisfy himself as to the matter of freshness. Fresh fish is firm and stiff; the drooping or not of the tails is a fair criterion in this respect. Flatfish keep better than herrings or mackerel. Cod, haddock and whiting keep the best, particularly if rinsed with salt water and stored in a cool place. All fish intended for food should be unbruised, unbroken and clean. If the scales are dull and damaged it is very suggestive of either ill-usage or staleness; softening in places indicates the same. It is an established fact that decomposition in the surface fishes, such as herring, mackerel and mullet, is extremely rapid. Ground fish, like halibut, cod and plaice, decompose much less rapidly, and if properly packed may remain fresh and fit for human food from seven to ten days after being taken from the sea. Fish which have been ungutted are the most difficult to inspect, more especially those with large, oily livers. Externally such fish appear good, the eyes being bright and gills red, but internally they are full of decomposition and decay. On strong pressure between the thumb and fingers the deeper flesh readily crushes, leaving only the skin between the fingers. This is an infallible test of unsoundness. Immediately after death the blood of fishes becomes coagulated. When decomposition sets in, on cutting the flesh, this blood will run out as a liquid of a dull red color, giving off an offensive smell. On removing the bones, in such cases, each one leaves a dull red mark, showing where the processes of decomposition are extending to the more solid portions of the fish. To avoid rapid decomposition, all fish should be at once bled and gutted on being caught.

The allowance of fresh fish in the ration is eighteen ounces. As already stated, however, this quantity is so reduced by unavoidable wastage, and the meat is so watery in character, that it is far inferior in nutritive value to the ration of animal flesh; the legal allowance of whole fresh codfish furnishing one hundred and fifty-five Calories where the ration of fresh beef supplies eleven hundred and eighty Calories. It is therefore evident that fresh fish, in the quantity authorized, is not suited for use by troops during periods of hard work; and even in garrison it should never be employed more than once weekly. As a general thing the wastage in fresh fish and its lack of a satisfying character are appreciated by company commanders, and issues of fresh fish are rarely made by the Subsistence Department—such fish as are desired being purchased from the company funds. The variety of fish which may be used as food is almost infinite; but taking into consideration the stations at which our troops are serving, the more important species which may presumably from time to time enter into the subsistence of the soldier—together with their chemical composition—will be found in the following table.

Whole fish.	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Bass, black	34.6	9.3	0.8	205
Bass, sea	34.8	8.7	.2	170
Blackfish	31.4	7.4	.7	165
Bluefish	40.3	10	.6	210
Cod	38.7	8.4	.2	165
Flounder	32.6	5.4	.3	115
Halibut (steaks)	61.9	15.3	4.4	470

Whole fish.	Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
Herring	41.7	11.2	3.9	375
Mackerel	40.4	10.2	4.2	365
Mullet	31.5	8.2	2.0	235
Perch, white	28.4	7.3	1.5	200
Perch, yellow	30	6.6	.2	130
Pike	29.7	6.6	.4	135
Pompano	39.5	10.3	4.3	375
Red snapper	42	10.8	.6	225
Salmon	40.9	15.3	8.9	660
Shad	35.2	9.4	4.8	380
Sheepshead	26.9	6.6	.2	130
Smelt	46.1	10.1	1.0	230
Trout	40.4	9.9	1.1	230
Weakfish	38.0	8.6	1.1	205

In its preparation, fresh fish is commonly boiled, steamed, broiled, fried or baked; or it may be combined with other materials in some made dish. When boiled, it is stated that the loss in weight ranges from five to thirty per cent., according to the species and length of cooking. One experimenter gives twenty-six per cent. as the average. This loss is largely made up of water, and little fat or protein is lost. So far as known, experiments have not been made which show the losses by other methods of cooking than boiling. It is probable, however, that there would be a very considerable loss of water by any method.

Dried Fish.—This, under favorable circumstances, is capable of preservation for at least a year; but the process of curing not only modifies the flavor but impairs digestibility. Preserved fish, as a rule, show a small percentage of refuse, with the exception of a few kinds which are preserved whole. The percentage of actual nutrients is naturally much larger than in the corresponding fresh fish, owing to the removal of a large part of the refuse and considerable fluid. The gain in nutrients is chiefly represented by protein, which is the most valuable nutrient. The allowance of dried fish, issued in the form of codfish, is fourteen ounces; the chemical composition of dry salt cod, as issued, being as follows:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
40.2	16.0	0.4	315

Bad codfish has a disagreeable odor and its hardness and consistency are notably diminished. In color such codfish is frequently reddish, the latter being due to a development of a growth—the Clathrocystis roseopersinica, according to Viry—which is of itself not poisonous but may often be a sign of the development of micro-organisms of a dangerous character. This red growth can be prevented by salting the codfish with a salt containing sodium sulpho-benzoate in the proportion of five per cent. by weight, or by dusting the fish with boracic acid. In the French service, where fish is regularly issued on Fridays, several outbreaks of ptomaine poisoning have followed the use of spoiled codfish. These outbreaks closely resembled those due to the use of meats of bad character.

Brieger has isolated a ptomaine from putrid codfish, which he considers identical with muscarin and which gives symptoms analogous to those following the use of poisonous toad-stools. There appears reason to believe that where fish are originally unsound, the processes of salting and drying serve to increase the capabilities of the fish as regards the production of irritant symptoms.

Care should be taken to see that codfish issued to troops is new, firm and white; and that it readily softens when placed in cold water and the latter brought nearly to the boiling point and kept at that temperature for an hour.

Pickled Fish.—The allowance of pickled fish is eighteen ounces, salt mackerel usually being employed for this issue. Pickled fish is rarely drawn, and then only for the sake of variety. It is not relished to any great extent by troops and could well be dropped from the ration. Its keeping qualities are, however, better than those of dried fish. The chemical composition of salt mackerel is as follows:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
34.8	13.9	21.2	1,155

Pickled fish should be stored in a cool, damp place and be kept well brined, as they soon become rusty and impaired in quality if the brine leaks out and leaves them dry.

Canned Fish.—Canned salmon is employed with advantage, as part of the ration, in the quantity of sixteen ounces. It is palatable and digestible, and its nutritive value, for fish, is relatively high. Used as an occasional substitute for meat it gives a welcome variety to the diet, especially for the lighter meals of the day. The fish is canned in its own juice and the original flavor is largely retained. In composition, canned salmon compares favorably with the fresh article. Generally speaking, the amount of refuse is small, since the portions commonly rejected in preparation for the table are also removed before canning. The following is the chemical composition of canned salmon:

Water, per cent.	Protein, per cent.	Fat, per cent.	Fuel value per pound, Calories.
56.8	19.5	7.5	680

Canned fish should never be allowed to remain long in the can after opening, but should be used at once. There is some possibility of danger from the combined action of the can contents and oxygen of the air upon the lead of the solder or the can itself. Furthermore, canned fish seems peculiarly suited to the growth of micro-organisms when exposed to the air, and the production of poisonous ptomaines is extremely rapid, especially under conditions of warmth, moisture and a deficient supply of oxygen.

THE BREAD AND VEGETABLE COMPONENTS.

Flour.—The inspection and preparation of grain, in the manufacture of flour, does not concern the military sanitarian, who has merely to do with the finished product. In the United States service wheat flour only is used, but in some northern countries, notably in Germany, where the production of wheat is less extensive, rye flour is much used in the preparation of bread for the soldier.

On account of the variation from the normal in the chemical composition of the wheat from which it is made, arising from the peculiarities of the kind of wheat or of the soil on which it was grown, or the meteorological conditions which prevailed during its growth, or a combination of these factors, flour will generally be deficient in some and redundant in other chemical elements essential to the production of good bread of proper nutritive value. These faults are, however, readily corrected by the miller, by properly mixing one or more brands of spring wheat flour with one or more brands of winter wheat flour. To make bread of proper nutritive value and wholesomeness, "straight" flour—which contains all the elements of the fully developed wheat grain, except the husk or bran—is essential, and flour of this character is the variety supplied for issue as a component of the ration, the daily allowance per man being eighteen ounces. The average chemical composition of such flour is as follows:

Water, per cent.	Protein, per cent.	Fat, per cent.	Carbohydrates, per cent.	Fuel value per pound, Calories.
12.8	10.8	1.1	74.8	1,640

Where large lots of flour are to be purchased or issued, the samples should be examined microscopically, physically, chemically and practically by making bread. This is particularly necessary in time of war, when flour is more liable to be adulterated by unscrupulous contractors. Detection of any such adulteration should be followed by the severest punishment of those responsible. Riordan states that: "The prompt action of the Russian authorities, during the Russo-Turkish campaign, on discovering that the flour furnished by the head of the commissarial department contained a large proportion of terra alba, is to be commended. The man who endangered the success of the enterprise was immediately shot for his dishonesty."

Ordinarily, when flour is purchased in small quantities, the physical and practical examinations will be sufficient. In appearance, flour should be of a warm white color, not a chalky white. The latter indicates deficiency in strength from over-grinding, which removes too much of the gluten and leaves the starch element too prominent. A bluish tinge indicates the presence of cockle seed—a small black seed borne by a weed which grows among the wheat—or smut, a fungous disease to which wheat is liable. The color which flour will give to bread made therefrom can be shown by placing a flattened ball of dough on a piece of window-glass and noting the color of the bottom through the glass after twenty-four hours.

On touching the flour there should be no lumps, or, if there are, they should at once break down on light pressure. There must be no grittiness; which shows that the starch grains are changing, are adhering too strongly to each other and will give an acid bread. There should, however, be a certain amount of cohesion when a handful of flour is compressed. When flour is damp it should be rejected without question. This condition is indicated by the possibility of rolling a pellet of it between the thumb and finger, or by the general feeling of moisture perceptible in running the open hand through it. Where more exactness is required in determining the water, the following method may be employed: Weigh 1 gm., spread it out on a dish, and dry either by a water-bath, or in a hot-air bath or oven, the temperature not being allowed to go above 212° F. The flour must not be at all burnt or much darkened in color. Weigh directly the flour is cold; the loss multiplied by one hundred is the percentage of water. The range of water is from ten per cent. in the best dried flours to eighteen per cent. in the worst. The more water the greater the liability of change in the flour and the less is the amount of nutriment supplied by a given weight. If, then, the water be over eighteen per cent., the flour should be rejected; if over sixteen, it should be regarded as of inferior character. Moisture, in the presence of heat, favors the development of the bacteria by which fermentative changes are produced. Fermenting flour produces gastro-intestinal disorders. The heat and moisture of the stomach doubtless excite at once very rapid fermentation, carbon dioxide is rapidly developed; hence uncomfortable feelings, flatulence, imperfect digestion and diarrhœa. It is to remedy this condition of the flour that alum is added, and some of the effects ascribed to alum may be really owing to the bad character of the flour itself. In some instances the flour may have been originally good, but altered either from age or imperfect drying. The bread made from such flour is often acid, and sometimes highly so, sufficient to produce diarrhœa; though such bread has sometimes been used for a long time without this effect—usually soldiers will not eat much of it and thus their supply of nutriment is lessened.

The taste of flour must not be acid, although the best qualities are slightly acid to test paper. If flour does not have the taste of sound, freshly-ground wheat meal, or if it has a sour taste or a musty, mouldy or earthy taste or odor, however slight, it should be rejected. Earthy smelling flour is made from wheat which has been exposed to dampness while in the straw. Bread made from such flour is clammy, heavy, dark-colored and unwholesome. To determine whether flour has absorbed any foreign odor, three or four ounces of it should be placed on a plate and drenched with boiling water. If contaminated in the above respect the foreign odor is readily noticed in the vapor.

The quantity and quality of the gluten present in a flour is a matter of great importance, and different kinds of wheat vary greatly in this respect. Gluten has a high nutritive value as an easily digested proteid; mixed with water it forms a tenacious, elastic body, which expands under the pressure of the gas from the yeast until the dough is full of vacuolations whose walls of tough gluten do not allow the contained gas to escape, and thus make the dough light and porous. The so-called hard wheats are rich in gluten of a strong, tenacious character, while soft wheats contain less glu-

ten and proportionately more starch. The gluten of hard wheat can be mixed with large amounts of water, and produces a large loaf from a comparatively small quantity of flour. Soft wheat, on the other hand, while it does not yield so large a loaf, makes a bread containing less water and having a milder and more agreeable flavor. In general, flour containing a satisfactory proportion of gluten should stick to a perpendicular flat surface when thrown against it. The strength of flour, or the amount and quality of its gluten, can also be determined with sufficient accuracy for all practical purposes from the elasticity and other characteristics of its dough. For this test, two ounces of the flour are mixed with one fluid-ounce of water —good flour absorbs water in about this proportion—and the mixture is thoroughly kneaded into a dough. The latter is then moulded into the form of a cylinder about two and one-half inches long and one and three-fourths inches in diameter. It is then placed on end on a flat surface and allowed to remain half an hour. If it stands up and retains its form well, and has acquired a hardened, dry surface, it is evidence of the sufficiency and good character of the gluten. If it falls, flattens or "runs," it is evidence that the gluten is deficient in quantity or quality—or both. If dough which has stood the first test satisfactorily be flattened out by pulling it around the ends until it is so thin as to be transparent, it is further evidence of good character; and if, when rolled in the form of a thin cylinder, it is pulled gently at the ends and the tension then relaxed, the dough retracts on itself and resumes its former shape, no further evidence as to its good character is required. The gluten may be determined with accuracy by weighing out 10 gm. of the flour and mixing it into a dough with a glass rod while water is slowly added from a burette. The dough is then allowed to stand about fifteen minutes, at the end of which time a little water is added, the dough worked with the rod and the starch poured off. This process is continued until the dough is so coherent that it can be worked with the fingers, when it is manipulated until the water which comes off is quite clear. The gluten is preferably weighed after drying on a water-bath. If weighed in the wet state the gross weight should be divided by 2.9 to get the amount of dried gluten. Dry gluten usually ranges from eight to ten per cent.; flour showing less than eight per cent. should be rejected.

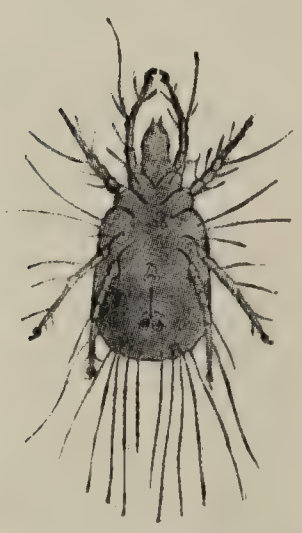


FIG. 79.—Tyroglyphus longior. (Much enlarged.)

Flour is in its best condition one to three months after milling. After this period it does not improve and ultimately undergoes deterioration. Animal and vegetable parasites appear in it, and its acidity increases rapidly and progressively. Under ordinary conditions, the period of good preservation of flour does not extend beyond a few months. In general, flour made from winter wheat has superior keeping qualities. No flour, however, will keep unless made from sound and well-cleaned wheat. The minute so-called flour mite—Tyroglyphus longior—is by no means uncommon in old, inferior flour, especially if it is damp. Its occurrence does not necessarily indicate that leguminous seeds are present, as sometimes stated. The presence of these mites always shows that the flour is beginning to change. A single mite may occasionally be found

in good flour, but even one should be looked on with suspicion, and the flour should be afterward frequently examined to see if they are increasing in numbers. These insects are capable of passing into a resistive stage in which they can exist without food for many months. If a storehouse be once infected, their extermination is a matter of considerable difficulty.

Several species of little flattened beetles, of a shining brown color and similar appearance generally, so frequently occur in bags and barrels of flour as to have earned the popular title of "flour weevils." They live upon cereals and other seeds and various other stored products, but generally prefer flour and meal and articles of diet containing farinaceous matter. Their eggs are often deposited in the flour in mills, and these and the larvæ



FIG. 80.—Tribolium confusum. *a*, Beetle; *b*, larva; *c*, pupa. (All much enlarged.)

they produce, being minute and pale in color, readily escape notice; but after the flour has been barreled or placed in bags and left unopened for any length of time, the adult beetles make their appearance and in due course the flour is ruined, for when the insects have time to propagate they soon convert the flour into a gray, useless mass. A part of the annoyance is due to the fact that the insects are highly offensive, a few specimens being sufficient to impart a disagreeable and persistent odor to the infested substance. While there are several allied varieties of these flour beetles, the most important is the Tribolium confusum, which is said to be the most destructive of all insects to prepared cereal foods. The mature insect is shining brownish-red in color, and is about one-sixth of an inch long.

Somewhat rarer pests are the larvæ of various kinds of moth, more particularly Ephestia kuehniella, belonging to the micro-lepidoptera. In this insect the adult moth has a wing expanse of a little less than an inch; the fore-wings are pale leaden-gray, with transverse back markings of the pattern shown in the accompanying illustration; the hind-wings are dirty whitish, semi-transparent, and with a darker border. The caterpillar is whitish and hairy. The chrysalis is reddish-brown.

For the destruction of all these flour insects exposure to weak fumes of sulphur dioxide is efficacious; but the quality of the flour is somewhat

injured for bread-making by this treatment. The method now generally adopted by millers for destroying these insects consists in spreading out the flour, so as to expose a reasonably large surface, in a small, fairly tight room. Bisulphide of carbon is then evaporated in shallow dishes, or on bits of cloth or cotton waste, distributed about on the surface of the infested material. The liquid rapidly volatilizes, and being heavier than air, the vapor descends and kills the insects in the flour or grain. While this liquid has a strong, disagreeable odor, this soon passes away. Its inflammability should be remembered. One ounce of the bisulphide is said to be sufficient for one hundred pounds of flour. For the fumigation of infested storehouses one pound to each one thousand cubic feet of space is required.

In flour which has gone to extreme decomposition, and is moist and becoming discolored, moulds and various forms of bacterial life are frequently seen. They cannot be mistaken.

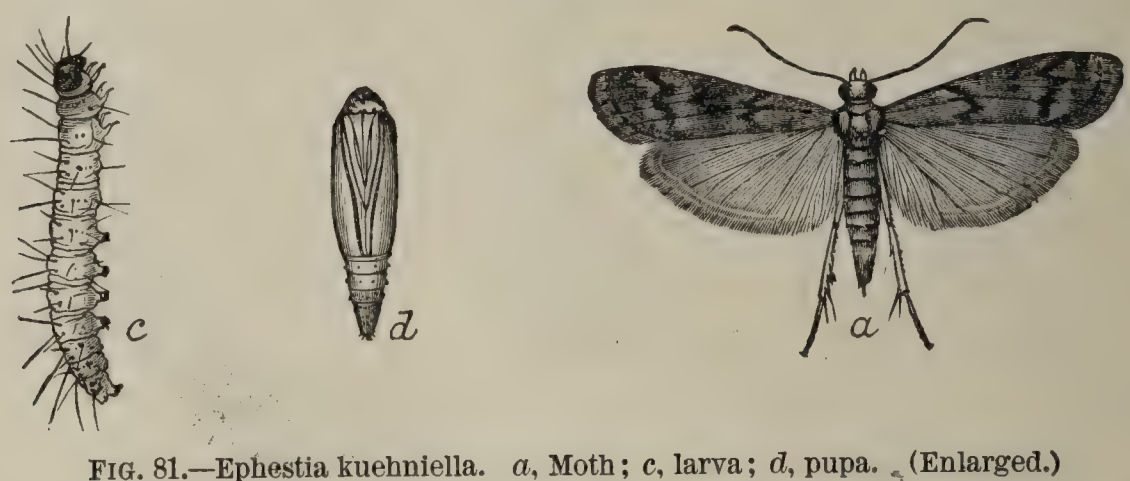


FIG. 81.—Ephestia kuehniella. *a*, Moth; *c*, larva; *d*, pupa. (Enlarged.)

Good flour cannot be made from sprouted wheat, because such wheat has undergone more or less fermentation and, although it may be given a satisfactory appearance by careful milling, it will not ferment sufficiently to make good bread. Such flour feels heavy and is dull, flat and lifeless. The dough made from flour of this character has a rank odor, and the bread is moist, heavy and dark colored. Occasionally flour from wheat grown on sandy soil, or where lime is deficient, may rise well enough, but the bread becomes heavy and sour when it cools. This is especially the case with Arizona-grown wheat. Good bread may be made from such flour by the use of lime-water.

The impurities which may accidentally gain entrance to a bag of grain, or even into the flour made from it, consist chiefly of the seeds of other plants and of blighted or moulded wheat. The foreign seeds most to be dreaded are perhaps cockles and darnel, and both should be carefully guarded against—cockles because they injure the color of flour and bread, and darnel because it is commonly regarded as poisonous. Other foreign seeds may not be equally dangerous, but they should be removed with equal care as they lessen the nutritive value and strength of the flour. In the United States there is undoubtedly little attempt at the adulteration of flour offered for military use. The adulterants which are most commonly used abroad are rye flour, corn (maize) flour, rice meal, potato starch and meals from various leguminous plants, such as peas or beans. They are not harmful in the food and sometimes improve the color of the bread; nev-

ertheless they are fraudulent because they lower the quality of the flour without harming its appearance. The mixture is sold as flour, and thus the Government would secure an adulterated article under a false name and at the same price as pure goods. The nature of these grains can be determined by the microscope. Mineral substances, such as alum, borax, chalk and carbonate of magnesia, are occasionally put into the flour to whiten it or to neutralize its acidity; but these are more often used by the baker than by the miller. When flour is suspected of adulteration with a mineral substance, it should be strongly shaken with chloroform. The flour floats, while all mineral matters fall to the bottom. Many other tests are given for the detection of special mineral substances, but these will rarely be required in the inspection of flour for the military service.

Flour keeps best in cool, dry and well-ventilated storage. Extremes of temperature should as far as possible be avoided, nor should flour be exposed to a freezing temperature. It is peculiarly sensitive to exhalations from other substances, and, therefore, should not be stored in proximity to articles which give rise to powerful or unpleasant odors. In general, flour sacks should be packed in tiers, but caking occurs in the lower layers if the tiers be too high.

Bread.—This, the other important part of the ration with meat—for practically bread and meat make up its nutritive value—is the only portion of it in which there is practically no unavoidable waste. Further, bread is very completely digested. It is not, however, a complete diet; being somewhat deficient in nitrogen and markedly so in fats. Greasy food is eaten with it by instinct, and unless fats are supplied, as bacon or rich gravy, it will often be wasted by troops. When used with other foods in proper proportion, it is much appreciated and can be eaten indefinitely without becoming distasteful.

The allowance of soft bread is the same as that of flour, eighteen ounces. It is possible, however, to increase the bread ration to the full extent of the flour ration, or any part thereof, under the concurrent authority of the post council of administration and the commanding officer. Under ordinary circumstances in civil life a pound of bread is made from three-fourths of a pound of flour—the additional weight being due to the water required in the process. With some flour five to ten per cent. more water can be absorbed, and in the military service the savings on a hundred-weight of bread are ordinarily calculated at about thirty-three pounds of flour. On the other hand, since many of the compounds formed during the fermentation process are either gases or are volatile at the temperature of baking, appreciable losses of dry matter necessarily take place. These losses are usually estimated at about three or four per cent. of the flour used. The chief difference in the composition of flour and bread is the proportion of water, which makes about one-eighth the weight of flour and one-third that of the bread. The average composition of bread, such as is used in our service, is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, per cent.	Fuel value per pound, Calories.
35.4	9.5	1.2	52.8	1,244

Where carbon dioxide is in any way formed within or forced into the interior of dough, so as to divide it into a number of minute cavities, bread is made. There are practically two kinds of bread—that made by means of yeast and that aërated by chemical means. In the first, the action of the yeast and heat results in fermentation of the carbohydrates and the production of carbon dioxide and alcohol; the production of soluble carbohydrates, as dextrin, from insoluble forms, as starch; the production of lactic and other acids; the formation of other volatile carbon compounds; the partial oxidation of the fats. Besides these there are many other changes, the nature of which is less well understood. The ordinary process of bread making consists really of three stages—namely, the preparation of the leaven or ferment, the preparation of the sponge and the making of the dough. The ferment is made by mashing boiled potatoes into a thin paste, cooling to about 80° F., adding sufficient good yeast and a little flour. The mixture is set aside in a warm place for about five hours; at the end of which time the yeast is very active and maltose, dextrin and peptone-like bodies have been found in the mixture. To this ferment, when ready, about one-third the flour to be used is added, together with sufficient water to form a stiff dough and a little salt. The resulting mixture constitutes the sponge, in which very active fermentation goes on. After about five hours the sponge breaks, owing to the development of large quantities of carbonic acid and alcohol from the maltose and dextrin. When the sponge has broken twice, the dough is formed by adding to the sponge the remainder of the flour and sufficient water. This rises in an hour or so, and is then transferred to an oven for an hour and a half. Though the temperature of the oven varies from 400° to 450° F., the actual temperature of the dough does not rise much over 212° F. In this stage the chemical processes are not very active; but the bread gradually becomes well aërated and its constituents, undergoing a kind of automatic digestion, improve both in flavor and aroma. Military bakers almost invariably prefer to use potato yeast rather than the compressed article.

The so-called "salt-rising" bread is interesting as an illustration of self-raised bread. In it the ferments originally present or acquired from the air produce the fermentation which leavens it. To make it, warm milk and corn-meal are mixed together into a stiff batter, which is left at blood heat until the whole mass is sour. Next a thick sponge is made of wheat flour and hot water, in which a little salt has been dissolved. This sponge and the sour batter are thoroughly kneaded together and set in a warm place for several hours. The leavening action started in the batter spreads through the dough and produces a light, porous loaf, which many persons consider very palatable. Such bread is quite free from acidity, as the presence of the salt prevents undesirable fermentation.

On an average there is about one per cent. by weight of alcohol produced when bread is made. It serves a useful purpose, since, in baking, the alcohol is volatilized, and the vapor aids the carbon dioxide in expanding the dough, thus making the bread more porous. Notwithstanding the loss of carbohydrates caused by the production of alcohol and carbon dioxide, fresh breads ordinarily contain from three to four per cent. of soluble carbohydrates. Allowing for average losses of carbohydrates by fermentation, not far from six to eight per cent. of the total insoluble starch,

originally present in the flour, is changed to soluble forms during the bread-making process. There are also other changes which the starch has undergone which are not shown by chemical analysis. By the combined action of the ferments and heat the forms of many of the starch grains in bread are materially changed. When bread is extracted with alcohol and water to remove a part of the proteids and the soluble carbohydrate bodies, the form of the starch grains may be distinctly seen. Many of these appear as if they had been partially digested, and many pieces of disintegrated starch granules are present. In some cases the outer layers of the starch grains appear as if they had been subjected to pressure and partially ruptured. Many of the smaller and medium-sized grains appear unaltered. These physical changes which the grains have undergone during the bread-making process doubtless render bread, when properly made, more susceptible to the action of solvents, as the digestive fluids.

In the non-fermented breads the necessary carbon dioxide is ordinarily generated by mixing sodium or ammonium carbonate with the dough, and adding hydrochloric, tartaric or citric acid. Baking-powders are compounds of these substances, well mixed and preserved in a dry state. The chief objections to such yeast substitutes are that unless carefully prepared they may be inefficient or harmful, that they are easily adulterated and that bread made from them is usually rather tasteless, lacking the flavor and aroma which good yeast imparts. Alum is often added to whiten bread and stop an excess of fermentation. It is frequently present in baking-powders, and when in excess interferes with digestion.

The "aërated" or Dauglish patent bread may here be mentioned. In this method the water used for wetting the dough is directly charged with the requisite amount of carbon dioxide gas, and then mixed with the flour in a specially constructed machine. Sometimes a little fermented barley infusion or wort, from a brewery, is put into the water. This aids it in absorbing the gas, renders the gluten more elastic and improves the flavor of the bread. Notter and Firth state that about twenty cubic feet of CO_2, derived from chalk and sulphuric acid, are used for two hundred and eighty pounds of flour; and that about eleven cubic feet of the gas are actually incorporated with the flour. It is claimed for unfermented breads that they do not contain alcohol, acetic acid and other products of excessive fermentation, but the advantage is a doubtful one, as the action of yeast partially digests the starch, changing it into maltose and dextrin, while the proteids of flour are also largely converted into albumoses or other peptone-like bodies. In general, it should not be forgotten that the lightness and sweetness of bread depend as much on the way in which it is made as on the materials used.

On pressing in a well-baked loaf of bread, without, however, breaking the surface, it should, if properly baked, spring back into its original shape. In good bread not less than thirty per cent. of crust should be present, this being yellowish brown, firm and not aërated. The external surface should be caramelized but not burned. The amount of crust is readily determined by paring it off with a sharp knife and weighing. The crumb should be permeated with small, regular cavities and no part should be heavy or without these small cells. The partitions between the cavities should not be tough, the color should be white and the taste not acid,

even when held in the mouth. If the color changes soon, and fungi develop, the bread is too moist; if sodden or heavy the flour is bad, the baking at fault or the sponge badly set. In the military service, bad bread is generally due to carelessness or inexperience on the part of the baker rather than to defect in the raw materials employed.

From the cheapness of flour, bread is rarely adulterated in this country —except where mineral salts are mixed into the dough for the purpose of producing a good-looking loaf from poor flour. Alum is the most common of these. It tends to check the action of the diastase and permits a weak flour to absorb more water than usual. It also improves the color of the bread. Many reliable bakers use it under the impression that it does good and not harm; but besides producing a bread the nutritive value of which is not so great as appearances indicate, it is believed to be really injurious to the digestive system and must be ranked as an objectionable adulterant. Alum tests are usually made by soaking a sample of the suspected bread in a solution of tincture of logwood and ammonium carbonate, in which alum betrays itself by a bluish color. Copper sulphate is used to produce an effect similar to that of alum in bread, but is believed to be more dangerous. Lime exerts practically the same influence and does no particular harm. In the military service bread is ordinarily baked from the flour provided by the Subsistence Department; and if the quality of the flour be good the purity of the bread is insured. Under certain circumstances, however, small bodies of troops may be temporarily without facilities for baking their own bread, and in such instances the ration of flour may be turned over to some civilian baker; he agreeing to supply an equal weight of bread and taking the flour savings for his labor. Under these circumstances special attention should be given to the quality of the bread—not only as regards the above mineral adulterants but also since dishonest bakers are apt to under-bake the bread so as to retain as much water as possible and thus increase the weight. It is also for their advantage to have the bread weighed out as soon as possible after baking, but this should not be done within twenty-four hours. After being taken from the oven bread begins to lose weight. This loss naturally depends upon size, amount of crust, temperature and movement of air, but in a sheltered place, at ordinary temperature, a two-pound loaf, baked with crust all over, loses about three-fourths of one per cent. in cooling and from one to one and one-fourth in five hours. A similar loaf, with only top and bottom crust, loses three per cent. in cooling and about four per cent. in five or six hours. A loaf with four sides crust loses two per cent. in cooling and retains its weight without much further loss for five hours. For each of six sides that is not crust there is a loss of weight of about one per cent. in the first five hours. At the end of twenty-four hours the proportion is about one-half more, and the total loss is doubled at the end of seventy-two hours. If the bread is baked in larger loaves the loss will be proportionately less, the ratio of the evaporating surface to the bulk of the loaf being diminished. In the German army bread less than twenty-four hours or more than four days old is not accepted for issue.

Bread may be of bad color from old flour, from grown flour—in which case the changes in the starch have generally gone on to a considerable extent, the bread contains more sugar than usual and does not rise well—

and perhaps from bad yeast. Bread may undergo lactic or butyric acid fermentation from the introduction of specific bacteria. In such instances it frequently happens that the vessels used in preparing the dough were not thoroughly cleaned after the last using; that the yeast contained an undue proportion of these bacteria; or, if the latter were found only in normal quantities, the yeast itself may have been weak and quickly exhausted. If the dough stands too long after mixing and the yeast ceases to work, the undesirable bacteria, which grow best in the presence of acetic acid, such as occurs after alcoholic fermentation has ceased, may undergo luxuriant development. In certain cases these bacteria may have been originally present in the flour itself and survived baking. Bread which grows sour with age has usually received its bacterial infection from the air. When sour bread has been produced, great cleanliness on the part of the bakers and their utensils should be enforced. When the flour itself is acid, lime water should be used instead of pure water to moisten the dough. The former has the advantage that, while it corrects acidity, it does not check the fermentation of yeast. Bread may sometimes be bitter from bitter yeast—the remedy for this is obvious.

One of the most common and dangerous faults in bread is heaviness and sogginess. This fault may be caused by the use of cheap flours, poor in gluten, which cannot absorb all the water put into the dough, or, to state it in another way, by the use of too much water in proportion to the flour; by too little or by too poor yeast, or by insufficient kneading, rising or baking. It is said, also, that if the flour has been dried at too great a heat the gluten is altered and the bread does not rise well. The practice of wrapping freshly-baked bread in cloths during cooling makes it damp and clammy. Heavy bread is one of the most indigestible of foods, since when chewed it rolls itself into solid lumps which afford little opportunity for the action of the digestive juices to act upon them. Occasionally the crumb of fresh bread breaks when cut, instead of separating cleanly under the knife. Harsh, dry flours, not sufficiently fermented, may be the cause of this—or the dough may have lost its tenacity by being overworked. Another common fault in bread is a crumb full of large, irregular holes instead of the small, even pores which it should show. These occur in over-kneaded or over-raised dough; or if they are found just below the crust they mean that the oven was too hot and that the crust formed before the carbon dioxide had finished expanding.

In the course of three or four days after baking, bread sometimes becomes sticky or slimy, assuming a light-brown tint and presenting a sweetish taste and peculiar odor. When touched, such bread appears sticky—a condition which ultimately may become so marked as to permit the production of threads which may string out several feet in length. This condition was shown by Russell to be due to the presence of the ordinary potato bacillus—Bacillus mesentericus vulgatus—and it was found that the temperature of the interior of loaves was not sufficiently high to destroy these bacilli in the spore condition. This bacillus appears to gain access to the bread through the medium of impure yeast. The trouble need not cause any special alarm from a sanitary standpoint, for the organism causing the change is a saprophytic form that is widely spread. As soon as the fermentative change begins to be well marked it is apparent

enough to the taste, so that bread affected with the same would be quickly rejected as food. The remedy consists in careful investigation into the character of the yeast supply, and, if necessary, the storage at a low temperature of bread liable to be affected in this manner.

Among the various species of bacteria which may occur in bread, mention should be made of the Bacillus prodigiosus, the occurrence of which gives rise to blood-red spots in the dough. This micro-organism is harmless—but from its striking appearance its presence is liable to give rise to considerable apprehension among those less well informed.



FIG. 82.—Aspergillus niger. *A*, Mycelium and spores; *B*, arrangement of spores (enlarged). (After Laveran.)

Bread, especially when moist or stored in a damp atmosphere, often serves as a medium for the development of moulds, the spores of which are floating everywhere in the air. Balland and Masson state that the temperature in the interior of bread during baking attains a height of 100° to 102° C. This heat, combined with the acidity of the bread, destroys ordinary pathogenic micro-organisms; but certain spores of high resisting powers are capable of subsequent germination. Many of the moulds are probably present in the wheat itself in the form of spores, and hence exposure of the bread to the air after baking may not be necessary to induce their development. With the more common varieties of these moulds the sanitary officer

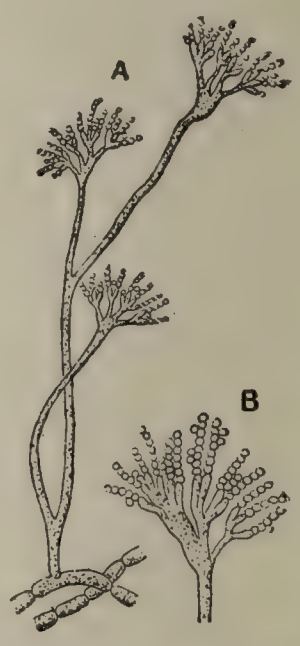


FIG. 82.—Penicillium glaucum, showing mycelium and spores (much enlarged). (After Laveran.)

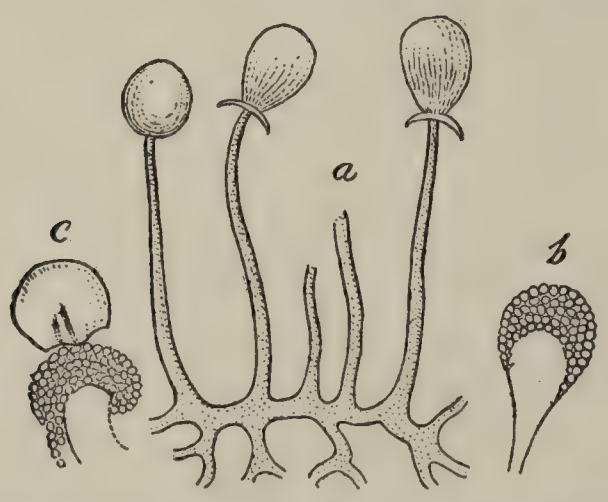


FIG. 84.—Mucor mucedo. *a*, Mycelium and spores; *b*, section of sporulating form; *c*, showing dissemination of spores (enlarged).



FIG. 85.—Rhizopus nigricans.

should be familiar, since bread so affected is unfit for food. Chief among these growths is the Penicillium glaucum, which forms the greenish patches so commonly observed on stale bread. Under the microscope the mould is seen to consist of ramifying filaments with characteristic brush-like extremities having a beaded appearance. These beaded extremities are due to the arrangement of the spores of the penicillium. Many varieties of aspergillus also find on bread a congenial field for their develop-

ment. Among these may be mentioned A. flavus, which produces yellow or light-brown spots; A. glaucus, which gives rise to greenish blotches similar to those produced by Penicillium glaucum, but distinguished from it by a more granular appearance; A. niger, which gives rise to black granular spots; and finally, A. albus, which gives white granular patches. Under the microscope aspergillus is readily distinguished from penicillium, the filaments terminating in a bulbous enlargement upon which the spores are disposed in a manner similar to that of a dandelion flower gone to seed. It is these spores which give to the spots produced by aspergillus their granular appearance. Three species of mucor are also found on mouldy bread. Of these, Mucor mucedo is the most common. It forms, on the surface of bread, spots which are variously white, gray or blackish. Under the microscope M. mucedo is seen to present a stem ending in a bulbous enlargement containing the spores and having a collar-like projection around the bottom of this enlargement. When the spores are matured the membrane by which they are covered is detached and the spores fall on all sides. As these spores are black, the patch made by this growth appears white, gray or black according to the period of development. Mucor racemosus forms a yellowish blotch; the filaments of this mould are shorter than in M. mucedo. Rhizopus nigricans, developing on bread, gives spots which are variously black or yellow. The growth is composed of short, ramifying filaments, terminating in bulbous extremities having a mushroom like appearance when the spores are matured. The Oïdium aurantiacum—a mould commonly found on bread—forms an efflorescence of a golden-yellow or salmon color and having a nauseating odor. Under the microscope the growth shows a ramifying network on which appear globular bodies containing the spores. The latter have a characteristic discoidal appearance. The Oïdium lactis gives white patches of a slimy appearance when developing on bread. Under the microscope the growth is seen to be made up of elongated cells placed end to end. The Oïdium albicans, an allied species, has much the same appearance. Oïdium aurantiacum has not infrequently been known to cause severe diarrhœa in persons who have consumed bread contaminated with this mould, and instances are given by Laveran in which similar symptoms have been produced by this agent in swine and horses. Viry mentions a case in which bread was covered with black and yellow mould forty-eight hours after baking, and this bread, fed to cavalry horses, produced paralysis. Rhizopus nigricans is believed to be especially dangerous. It is probable

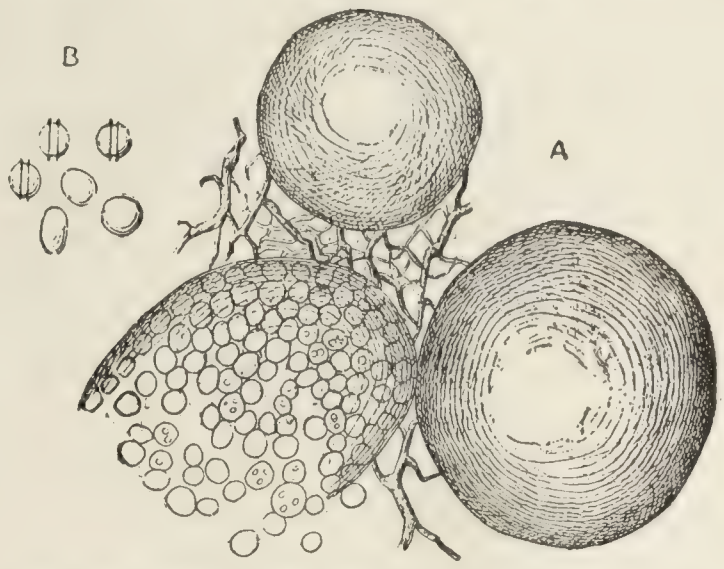


FIG. 86.—Oïdium aurantiacum. *A*, Mycelium; *B*, spores (enlarged).

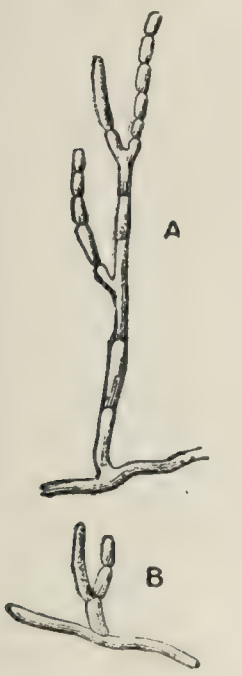


FIG. 87.—Oïdium lactis. *A*, Mature form; *B*, young form.

that all moulds found on bread, through the changes which they induce and the toxins to which they may give rise, are more or less dangerous—the degree probably depending to a considerable extent upon the physical condition of the consumer. From what has been said it is obvious that bread not immediately to be eaten should be stored in clean, dry and tight receptacles, preferably of metal or earthenware, and the latter sunned and sterilized at frequent intervals. The not uncommon practice in our service of keeping bread exposed to the air in damp, dark cellars or closets should be guarded against.

As a general rule, bread for troops should not be issued earlier than twenty-four hours, nor later than forty-eight hours, after baking. Too fresh bread is unhealthful and the wastage is considerable, since many soldiers eat only the crust of such bread and reject the damp crumb. Hence, from an economical as well as sanitary standpoint, stale rather than fresh bread should be issued. In instances where the loaves have become too hard and dry they can be re-baked—the moisture being driven from the crust into the crumb by this procedure, and the bread thereby freshened. An even better plan is to dip the loaves into water before re-baking. Such warmed-over bread, however, rapidly changes and must be eaten within twenty-four hours. It also lacks the elasticity of the fresh loaf and its interior crumbles as easily as before it was re-heated. Stale bread cut into thick slices and toasted is thereby freshened; bread sour from an excess of acid will become more edible through volatilization of the acid if cut into thin slices and toasted.

As great cleanliness should be observed in handling bread as in making it. In some post bakeries it is stored in places where dust and dirt can get to it, or is handled by unclean persons and transported to the place of consumption in dirty receptacles. When fresh bread is to be shipped considerable distances to troops in the field, particularly if by wagon transportation, the loaves of bread should preferably be wrapped in paraffin paper; this serving the double purpose of keeping off dirt and preventing the bread from drying. For transportation, loaves should be placed on the side or end, not on the bottom. An army wagon will carry, with side-boards up, eighteen hundred rations of bread.

Hard Bread.—Hard bread is made from unfermented or slightly fermented dough, from which most of the water is expelled during the process of baking. Its keeping powers are far superior to ordinary bread, for which it is temporarily a fair substitute under conditions where the latter cannot be obtained. Weight for weight it is much more nutritious than soft bread, on account of the small quantity of water present. It is, however, markedly deficient in fat, and the latter cannot be introduced into its composition on account of the rancidity which early results. The average chemical composition of hard bread is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, per cent.	Fuel value per pound, Calories.
9.2	14.4	1.3	72.8	1,712

Hard bread should be of a light yellow color, possess an agreeable taste and odor, be resonant when struck and dry to the touch, present no large

cavities and be well cooked without being burnt. The latter is important not only for the sake of driving off the water but also to increase digestibility through the conversion of a certain amount of starch into dextrin. Good hard bread should float and partially dissolve in water, and when placed in the mouth should thoroughly soften down. Other things being equal, the best hard bread is that which becomes soonest softened when soaked in hot water. The bread best responding to this condition is one slightly aërated, its substance being evenly pervaded with minute vacuolations. The density of the bread is lessened by this porosity, but the advantage given above more than offsets the slight additional bulk, through the lessened danger of diarrhœa among the users. Such vacuolated hard bread is far more readily acted upon by the digestive juices than is a denser article. While salt improves the flavor of hard bread it increases its liability to absorb water and impairs its keeping qualities—hence this substance should be added only in cases in which the hard bread is intended for immediate use.

Valuable as hard bread is for field use, it soon becomes difficult of digestion, and in the dry state, when improperly masticated, the sharp irritating fragments are directly provocative of diarrhœa. Further, troops early acquire a certain aversion to hard bread, and hence it should be issued only in instances where it cannot be avoided. Every effort should be made to insure that it is not used more than four or five days successively. Hard bread should preferably be softened before use by steeping in some fluid; but soaking in water makes it pulpy and unsatisfactory and coffee, soup or similar liquids are not always obtainable. It is sometimes softened in water and then fried in bacon fat. This renders it tough and indigestible, and such a method of preparation is to be strongly discouraged.

Weevils not infrequently make their appearance in hard bread, but can be destroyed by putting it into a bake oven and subjecting it to a temperature of 230° to 240° F. for the period of thirty minutes; or the hard bread may be spread out on a clean sheet or paulins and exposed to the hot sun for several hours. To prevent deterioration and protect against parasites, bread of this character intended for the French army is put up only in the cold weather months and is packed in tins or wooden boxes having the joints hermetically sealed with stout paper. When properly packed and stored, hard bread is good for about a year, but if exposed to a damp atmosphere it soon becomes mouldy.

Hard bread was formerly put up in large rectangles, but this practice is now discontinued and it is issued only in cakes about one and one-half inches square. Large biscuits appear to be more difficult to masticate than those of smaller size. Hard bread is now conveniently issued in one-pound stiff cartons. There is no waste, as formerly occurred to the large squares by crumbling when taken out of the original box.

Pain du Guerre.—In this connection note may be made of the "war bread" developed in the French service to remove the defects above noted as attaching to ordinary hard bread. At first, fresh issue bread was partially desiccated in the military bake-houses and then compressed, remaining fairly soft and suited for use in soup. It required, however, about a month to reduce the water in a loaf down to twelve or fourteen per cent.,

and when the residuum was moistened for use its edible qualities were regarded by troops as far from satisfactory. Private enterprise along these lines was also enlisted by the Government, but the result was a series of more or less complete failures. In December, 1892, the war office decided on making an extended trial of the compressed bread of Perrier, and after a two years' trial the reports received were fairly favorable. Before reaching a definite decision in the matter, however, the war office called upon all persons engaged in the baking trade to produce "a substance occupying very small space, but including, nevertheless, the whole of the qualities, nutritive and digestive, of ordinary bread." The required product was to keep good for a year without deterioration, its dimensions were to be such as to admit of its being readily packed in the soldier's valise, and its substance was to be sufficiently resistant to withstand the shocks of ordinary transportation. The materials used were to consist exclusively of wheaten flour, leaven, water and salt. In shape, each piece was to be square or rectangular, with a due proportion of crust. The crumb was to be white and porous, and both the taste and smell agreeable to the senses. Finally, the dryness must be perfect, there must be no crumbling and every loaf must swell out to the standard size within ten minutes after immersion in water at 50° C. The competition failed to produce a specimen superior to Perrier's compressed bread, and the latter has, since 1895, been definitely adopted in lieu of hard bread in the French army. In appearance this bread somewhat resembles the biscuits for dog food now on the market. It takes up water more readily than ordinary hard bread, but, according to Laveran, remains in good condition after immersion in water and drying in the sun or by the fire. In soup, it is said to take up eight times its own weight of liquid. It has, however, the disadvantage of requiring about thirty minutes to soften completely in water, is more costly than ordinary bread and is not as palatable as fresh bread. It is believed by French authorities to be much superior to ordinary hard bread; but this opinion, after due consideration of the merits of both articles, was not shared by the board of officers, in our own service, appointed for the purpose of devising an emergency ration. The process of manufacture of pain du guerre is a military secret—but it is said to be a true fermented bread.

Laveran states that a compressed aërated bread has been given careful trial in the Austrian army, as a result of which it has been formally included in the ration of that service.

Fresh Vegetables.—These are always desirable to afford variety, for their own sake as food, to stimulate the appetite, to aid digestion and prevent constipation. They are most important in the prevention of scurvy.

Fresh vegetables were formerly not supplied to troops in the United States service, their addition to the ration being of comparatively recent date. In the earlier reports concerning the food of soldiers after the Civil War, it was commonly stated that, on the frontier, vegetables were scarce and correspondingly dear. Many complaints about the lack of vegetables were made—a deficiency thought to be in no small degree responsible for the high percentage of desertions occurring at that time—and numerous requests that potatoes and onions be added to the ration were made. A general scorbutic taint pervaded the troops during this period, and serious outbreaks of scurvy occurred at several of the frontier stations, notably in

the southwest. To relieve this condition at some of the posts, watercresses were planted in the neighboring creeks, gathered and eaten—and gardens were established where practicable. A few years later an improvement was observed; attributed to better transportation facilities, which enabled the company savings on bacon, flour and sugar to be expended on vegetables. In many instances the soldiers themselves contributed toward the purchase of an additional supply of vegetables, often as much as a dollar a month per man. At present the vegetable component of the ration—besides beans, peas, rice and hominy—includes one hundred per cent. of fresh potatoes; or eighty per cent. potatoes and twenty per cent. onions; or seventy per cent. potatoes and thirty per cent. canned tomatoes, or other vegetables. No savings from these are purchased by the Government, and in time of peace, at established posts, the quantities allowed may be considered as ample. Partly, however, on account of the small nutritive value of vegetables in proportion to bulk and weight, and partly on account of their perishable nature, there will always be great difficulty in securing their actual issue during campaign, especially under adverse climatic conditions—that is to say, there will be the greatest risk of failure just when they are most needed. But the recognition of their importance and the attempt to supply them constitute a true sanitary advance. The large amount of vegetables used in continental armies is worthy of remark, and the taste for this class of food is doubtless increased by the foreign methods of cooking, which appear to be superior in many ways to our own.

The hygienic examination of fresh vegetables is by no means as important as that of meats, but still should not be neglected. If they have become too old and woody, they are inferior in nutritive value and are imperfectly digested; stale vegetables are equally inferior in value and far from appetizing. In general, they should be of good varieties, of reasonably large and uniform size, fully matured, dry, free from cuts and dirt and in all respects of good quality and in good condition.

Where vegetables are watered with sewage or drainage containing the ova of the animal parasites, these may find their way into man and undergo development; pathogenic bacteria may perhaps be introduced in the same way, and there is reason to believe that in this manner watercress, growing in sewage-polluted streams, has been on several occasions the source of enteric fever outbreaks. In time of epidemic the fresh vegetables used should be carefully selected and thoroughly cooked. The use of salads or vegetables in the raw state should be interdicted, as they are frequently contaminated with pathogenic micro-organisms through handling or washing. In the southern states and in the tropics, vegetables rapidly deteriorate and undergo decay. It is provided that such as have undergone deterioration shall be issued in increased quantities on the recommendation of a board of survey.

In garrison or permanent camp, where conditions permit, gardens should invariably be cultivated by troops. These permit of a considerable saving of the ration through the vegetables which they furnish, and also supply a variety to the table which is much appreciated by the men. Certain stations, unfortunately, afford no facilities for gardens—and in the field gardening is, of course, impracticable. There is no work more cheer-

fully performed by soldiers, or accruing more directly to their advantage, than the cultivation of vegetables for their own use.

Dried or desiccated vegetables of excellent quality are now produced. As antiscorbutics they are inferior to fresh vegetables and the latter should always be supplied when possible. Dried vegetables may have a place in the ration during campaign, where transportation is limited and distances are great. To meet these indications they are supplied in various foreign services.

Potatoes.—The white potato enters into the ration in the quantity of sixteen ounces daily; a deduction from this allowance being made where canned tomatoes, onions or other fresh vegetables are also drawn. Potatoes may be considered as occupying a place next in importance to the seeds of the cereals as a vegetable food, and are of particular value since their preparation may be largely varied and the system does not soon weary of their continued use. The juice of the potato is acid, due to the presence of a certain amount of free citric acid and the citrates of potassium, sodium and calcium, these rendering it particularly efficacious in the prevention of scurvy. As the amount of these salts is small, a considerable quantity of potatoes should be taken daily—at least ten or twelve ounces if no other vegetables are eaten. Being rich in starch but poor in protein and fats the potato serves excellently to supplement the meat ration. The percentage of water is high, though not so much so as in turnips, cabbage and similar foods. When properly prepared, potatoes are very digestible as regards the carbohydrate element, ninety-three per cent. of this being digested. The protein, however, is less readily acted on, seventy-two per cent. only being digested. The waste in potatoes, as ordinarily prepared, is about twenty per cent.; the average chemical composition of the edible portion being as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
78.9	2.1	0.1	18.0	380

Potatoes for army use should be of medium size. The very large ones are coarse and often hollow, while with very small ones, if peeled before cooking, the loss is considerable. The specific gravity of potatoes should be greater than that of brine containing 2.25 ounces of salt to the pint. Other things being equal, the greater their specific gravity the better their quality. They should be smooth, firm and free from worm holes and potato rot. On section they should cut with considerable resistance, being brittle rather than otherwise. If sprouting has occurred it can be detected by a close examination of the eye or by cutting just under the skin; the base of the eye enlarges inside as the potato sprouts, and such potatoes generally present a shrivelled appearance. Sprouted potatoes are unfit for use from the solanin which they contain. Viry gives an instance in which poisoning was believed to have occurred from this substance; and Coustan mentions a case in which one hundred and one soldiers were poisoned by eating sprouted potatoes. The symptoms produced were similar to those of belladonna poisoning. Fed to animals, these potatoes produced the same

symptoms. The quantity of starch present is an excellent indication of the cooking qualities, and also whether, after cooking, the potato will be wet and soggy or dry and mealy. This may be estimated by bisecting the potato, perpendicularly to its long axis, with a sharp knife. The condition of the cut surfaces as to moisture should be observed, and where the moisture is sufficient to drip when the cut surfaces are held at an angle with the floor, the potato will be soggy and poor when cooked. If the two cut surfaces be placed together and rubbed against each other with a circular motion, the resulting white froth will be thick and tenacious if the potato be of good grade, and weak and watery if of inferior quality. On pressing the cut surfaces together, the degree of richness of the potato will be shown by the greater or less tenacity with which the parts cling to each other. The best test of quality, however, is given by cooking. Potatoes affected with Phytophera infestans, or potato rot, are shown by the presence of dark-brown spots, a peculiar flat mouse-like odor, and a reddish, marbled appearance on section. The nature of the fungus can be determined by the microscope, if necessary.

Potatoes are best stored in a cool, dry and well-ventilated place, and should not be exposed to the light more than is necessary. They should be frequently picked over and the spoiled tubers removed. Potatoes rapidly deteriorate in hot climates, and are best preserved under such conditions by spreading them out in a thin layer exposed to the air. As mentioned elsewhere, they may be preserved in the fresh state by slicing and packing in molasses. On a small scale, the boiling of potatoes will keep them for some time. Cold storage, several degrees above the freezing-point, is of course the best method of preservation.

Onions.—These may be drawn by the soldier in the amount of 3.2 ounces daily and are much appreciated as a savory and wholesome component of the ration, both as a food and condiment. The waste in preparing onions is ordinarily about ten per cent.; the average chemical composition of the edible portion being as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
87.6	1.6	0.3	9.9	225

One of the special qualities of the onion is the presence of a pungent, volatile oil, to which its characteristic taste and odor are largely due.

Onions for army use should be firm and the outside leaves crisp. If they have sprouted, the fact can be determined by cutting them open. Dishonest dealers frequently cut off the sprouts and twist the outside leaf over the cut so as to conceal it. Onions should be free from defects, dry and solid. An onion pulled before it has thoroughly matured will have more or less moisture on the outside and be soft in spots. Overgrown onions are not desirable, being generally less firm and of poorer flavor than those of average size. This vegetable will stand a greater degree of cold without injury than will potatoes; if frozen, those thawed out slowly in a dark place are not much injured for immediate use. The white variety possesses the sweetest and mildest flavor, but the better keeping qualities

of the yellow and red varieties render them far preferable for storage purposes. Onions are very perishable and are best kept in a single layer on narrow slatted shelves, arranged one above the other at convenient distances.

Tomatoes.—Canned tomatoes are wisely included in both the service and travel rations—their issue in the latter being allowed after four days' continuous travel. In the former ration the quantity is 4.8 ounces, while in the latter the daily allowance is 16 ounces. The tomato is a better antiscorbutic than the potato. Its acid is malic, which it holds free at about .3 per cent. and about as much in combination with bases. The tomato is excessively watery, and, as ordinarily supplied, the solid constituents of the canned article, after straining, vary from fifteen to fifty per cent. It would seem as if some definite standard should be required in this respect; for where the fluids are in high proportion the Government pays for the purchase and transportation of water and the soldier is largely defrauded of an article with which it was intended he should be well supplied. The practice of accepting the lowest bid, and requiring no definite standard for the goods, is naturally fatal to quality and forces articles of the best character out of competition. Under the ordinary processes of canning a considerable number of cans undergo fermentation and are spoiled. It has recently been found that this fermentation can be almost wholly prevented by processing at a high temperature with superheated steam, and without deterioration in quality of the contents. Reprocessed cans are always of poor quality. They are those in which leaks are detected after processing, and are known by the presence of an undue amount of solder along the seams. Canned tomatoes stand extremes of climate without apparent deterioration. The average chemical composition of canned tomatoes is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
94.0	1.2	0.2	4.0	105

Other Vegetables.—Besides potatoes, canned tomatoes and onions, the legal ration provides for the issue of "4.8 ounces of other fresh vegetables not canned, when they can be obtained in the vicinity of the post or transported in a wholesome condition from a distance." As a matter of fact, advantage is rarely taken of this provision within the limits of the United States, and such other vegetables as are used by troops are either derived from post gardens or are purchased from the company funds. At stations where transportation facilities are poor or the facilities for keeping fresh vegetables are inadequate, particularly in the tropics, it may frequently be necessary to rely upon vegetables grown in the vicinity. For the convenience of sanitary officers, therefore, the averages of analyses of the vegetables not specifically named in the ration, but liable to enter to some extent into the subsistence of troops, are here inserted. In preparing fresh vegetables for the table a waste of fifteen to twenty per cent. should ordinarily be expected.

Article.	Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
Beans, butter, green, edible portion	58.9	9.4	0.6	29.1	740
Beans, lima, fresh, edible portion..	68.5	7.1	.7	22.0	570
Beans, string, fresh, edible portion.	89.2	2.3	.3	7.4	195
Bees, fresh, t edible portion.....	87.5	1.6	.1	9.7	215
Cabbage, fresh, edible portion.....	91.5	1.6	.3	5.6	145
Carrots, edible portion.....	88.2	1.1	.4	9.3	210
Cauliflower, edible portion.....	92.3	1.8	.5	4.7	140
Corn, green, edible portion.....	75.4	3.1	1.1	19.7	470
Greens, beet, cooked.....	89.5	2.2	3.4	3.2	245
Lettuce.....	94.7	1.2	.3	2.9	90
Parsnips, edible portion.....	83.0	1.6	.5	13.5	300
Sweet potatoes, edible portion.....	69.0	1.8	.7	24.4	570
Radishes, edible portion	91.8	1.3	.1	5.8	135
Sauerkraut	88.8	1.7	.5	3.8	125
Spinach, fresh.....	92.3	2.1	.3	3.2	110
Tomatoes, fresh.....	94.3	.9	.4	3.9	105
Turnips, edible portion.....	89.6	1.3	.2	8.1	185
Yams, edible portion.....	71.86	1.0	.2	25.05	500
Ripe bananas, edible portion. Used as a vegetable in the tropics.....	75.3	1.3	0.6	22.0	460

Cooking of Fresh Vegetables.—Vegetables shrink in bulk about ten per cent. in cooking, besides which a certain proportion of the nutritive principles are lost in the process. The latter is a matter of far greater importance than is commonly appreciated.

Vegetables contain a large amount of water, dissolved in which are considerable amounts of soluble inorganic compounds or salts, and more or less soluble organic substances—such as sugar and soluble protein compounds. The solid matter of vegetables consists largely of microscopic cells filled with starch grains. The walls of these cells are composed of cellulose or woody fibre, which resists the action of the digestive juices; and it is for this reason that the raw vegetable is, as a rule, unfit for food. When, however, heat is applied, the starch grains absorb the water from the juice, swell up and finally burst the cell walls, so that the texture of the vegetable becomes soft and the nutrients are easily attacked by the digestive juices.

Heat is usually applied by boiling, frying or baking, the first being the method most commonly used. During the process of boiling vegetables there is, of course, more or less opportunity for nutrients soluble in water to be dissolved out and lost. Indeed, much of this matter is already in a state of solution in the juices. The nutrients which would be liable to suffer such loss are, as mentioned above, some of the protein compounds, some of the mineral constituents, such as salts of potassium and sodium, and especially the sugars. The starch would suffer no appreciable loss in this way, owing to its insolubility. It might, however, be removed mechanically from the soft cooked vegetables under certain conditions. Of the protein compounds, those which are of the most value to the body are coagulated and thus rendered insoluble before the boiling-point is reached, behaving like the white of an egg under similar conditions. The loss of the more valuable portion of the protein would, therefore, take place before the water became sufficiently hot to cause coagulation. Some nitrogenous

substances are, however, soluble in water at all temperatures, and would thus be liable to loss during the entire process of boiling. Sugar is present in considerable quantity in some vegetables, and in such cases the loss of nutrients may amount to a considerable fraction of the original nutritive value.

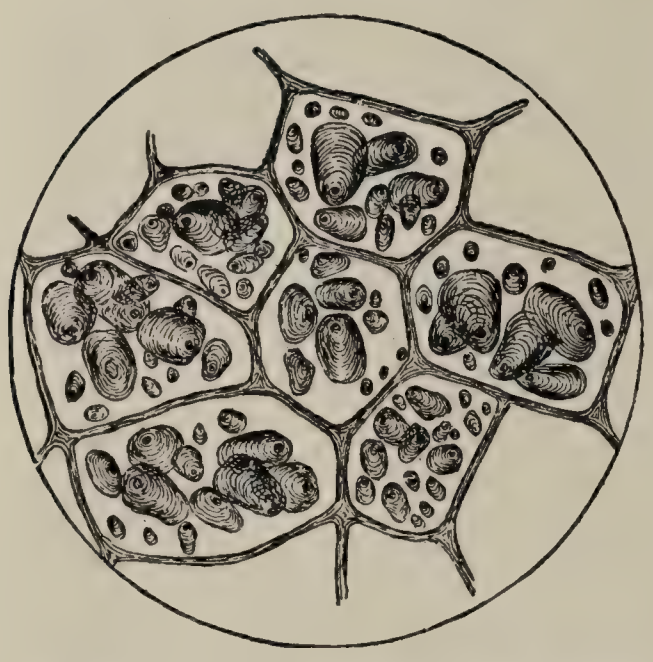


FIG. 88.—Cells of a Raw Potato, with Starch Grains in Natural Condition.

With reference to potatoes, it was recently found by Snyder and Bryant that, when peeled and soaked for several hours before boiling, the loss amounted to fifty-two per cent. of the total nitrogenous matter and thirty-eight per cent. of the mineral substances; when the potatoes were peeled and put into cold water, which was then brought to the boiling-point as soon as possible, the loss was much less, amounting to about sixteen per cent. of the nitrogenous matter and nineteen per cent. of the mineral substances. Potatoes peeled and placed at once in boiling water lost but half as much nitrogenous matter as in the preceding case, although the loss of mineral salts was practically the same; when potatoes were cooked with their skins on there was but a trifling loss of material, either nitrogenous or mineral. The character of the water, whether hard or soft, had but little influence on the result. In none of the experiments was there any appreciable loss of starch other than that resulting from the abrasion of the peeled potatoes during the latter part of boiling, when they had become soft and mealy. With reference to the mineral matters dissolved out it should be remembered that these salts, while not nutrients in the sense in which this term is frequently used, are nevertheless important in nutrition. They are of especial value because of the potassium compounds which they contain, and are apparently necessary for health. The conclusions drawn from these experiments may be briefly summarized as follows:

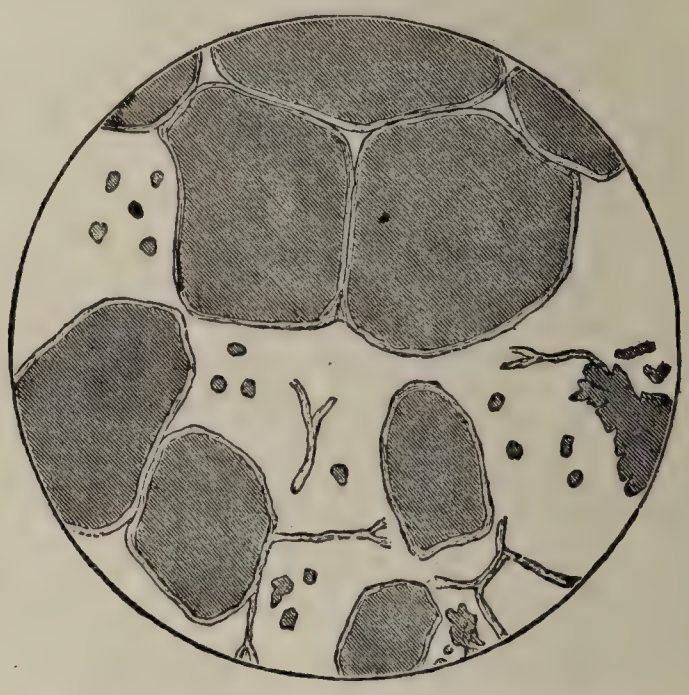


FIG. 89.—Cells of a Thoroughly Boiled Potato.

In order to obtain the highest food value, potatoes should not be peeled before cooking.

When the potatoes are peeled before cooking, the least loss is sustained by putting them directly into hot water and boiling as rapidly as possible. Even then the loss is very considerable.

With reference to the effect upon boiling of roots, such as carrots, beets and parsnips, investigation upon the first named vegetable, cut into wedge-

shaped pieces averaging about four inches in length, showed a total loss in the smaller pieces amounting to thirty per cent. of the total food material; or more specifically, to forty-two per cent. of the nitrogenous matter, twenty-six per cent. of the sugar and forty-seven per cent. of the mineral constituents. It appeared to make comparatively little difference whether the water used was hard or soft, or if it were hot or cold at the start. The medium-sized pieces lost the same amount of sugar as the small pieces, but less nitrogen and less mineral matter. As was expected, the least loss occurred when large-sized pieces were used; but even then it amounted to one-fifth of the total nutrients, one-fifth of the nitrogenous matter, one-sixth of the sugar and over one-fourth of the mineral constituents. When it is considered that carrots really contain as much water as is found in milk, it is readily seen that with the loss of from one-fifth to one-third of the whole nutritive matter there is no great food value left in the cooked vegetable. The loss of sugar during the boiling of carrots is equivalent to nearly one pound of sugar in a bushel of the vegetable. It appears, therefore, that in order to retain the greatest amount of nutrients in the cooking of vegetable roots, the pieces should be large rather than small; the boiling should be rapid, in order to give less time for the solvent action of the water to act upon the food ingredients; as little water as possible should be used, and unless the matter extracted be used as food, instead of being thrown away, the loss of twenty to thirty per cent.—or even more—of the total food value may be prevented.

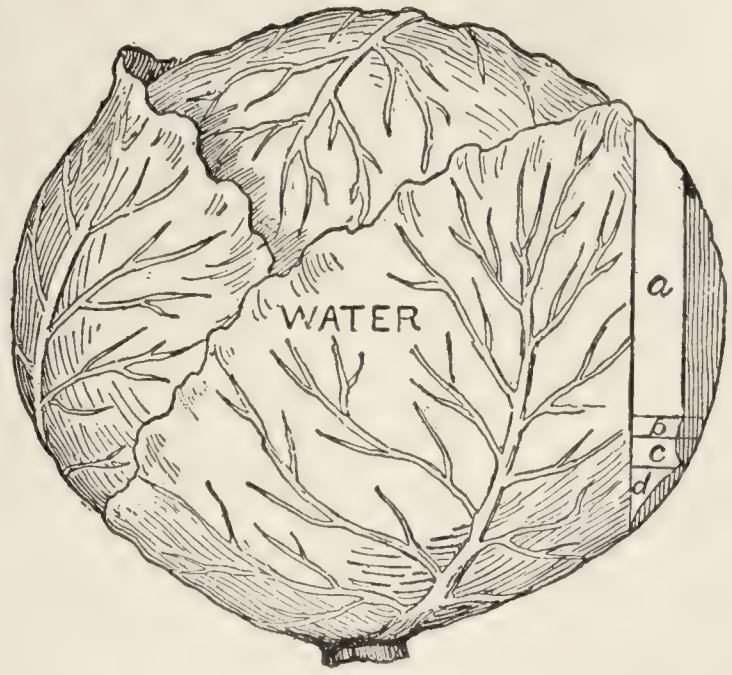


FIG. 90.—The Composition of the Cabbage and the Loss of Nutrients when Boiled. *a*, Starch, sugar, fibre, fat, etc.; *b*, non-albuminoid nitrogenous matter; *c*, albuminoid nitrogenous matter; *d*, mineral matter. The hatched portion represents the loss.

Taking cabbage as a type of pot herbs in which the leafy portion is the part eaten, similar experiments showed that the kind of water (hard or soft) has more effect on the loss of nutrients than the temperature of the water when the cabbage is placed therein. In any case the loss of nutrients was found to be very great, amounting to one-third the total nutrients when soft water was used, and two-fifths when the water was hard. The loss of the more valuable albuminoids was comparatively small, although the total loss of nitrogenous matter ranged from thirty-two to forty-six per cent. of the total. More than half the mineral salts were removed, and from twenty-eight to forty-two per cent. of the carbohydrates. In a cabbage weighing three pounds there are but four ounces of dry matter; the remaining two and three-fourths pounds is water. Of this four ounces, from one and one-fourth to one and three-fourth ounces may be lost during the cooking, leaving as much nutriment available from a three pound cabbage as would be contained in about two heaping tablespoonfuls of sugar.

This loss seems to be unavoidable unless the cabbage is cooked in such a manner that the water in which it is boiled is also used. This is frequently the case when it is cooked with corned beef. In the Russian army the water in which cabbage is boiled is invariably utilized in the preparation of soup, thus securing all the nutritive constituents of the vegetable for consumption by the soldier—and the same is true of the other vegetables used in the foreign services, in which soups and stews are the usual methods employed in the preparation of the ration.

Of the other methods of preparation, frying presents the objections already advanced with reference to the cooking of meats, as well as entailing a considerable waste through peeling. As already noted, stewing insures the use of all the nutritive principles of the vegetable to the purposes for which it was provided. Roasting in the ashes, a common method of preparing potatoes in the field, is wasteful, since carbonization of a considerable proportion of the vegetable is the rule. Baking is excellent, but care should be taken to select potatoes of the same size throughout, to insure evenness of cooking. The waste and loss by baking is small.

DRIED VEGETABLE COMPONENTS.

Beans and Peas.—These belong to the Leguminosæ, and in respect of their dietetic properties are broadly distinguished from other vegetable foods by their large amount of nitrogenous substance, called legumin or vegetable casein, which is probably largely derived from certain globulins and albumoses present in these seeds. The advantages of peas and beans as articles of diet are their richness in legumin and salts, especially those of potash and lime. Their disadvantages lie in their great indigestibility, and poorness in fat and sodium chloride. Rubner has shown that from about twenty-one to thirty per cent. of the nitrogen of peas passes out undigested in the fæces, as compared with thirteeen and fourteen per cent. of the nitrogen of white bread and about seventeen per cent. of black bread. The existence of sulphur frequently causes flatus from the production of hydrogen sulphide. Still, they are most valuable articles of food and ought to be much used during campaign, as they constitute an excellent addition to bacon, bread and the cereals. Both men and beasts can be nourished on them alone for some time, and in fact, added to rice, they form a staple food for large populations of India and other tropical countries. When fat is added, as in the common method of preparing baked beans, they form an article of diet well calculated to fulfil all the nutritive requirements of the organism. The daily allowance of either beans or peas is 2.4 ounces, a quantity which appears to be amply sufficient.

As too often cooked in the military service, beans are tough and indigestible and favor the occurrence of intestinal disorders. There is nothing more true—at least for the field, where time for their proper preparation is often wanting—than the old saying that "beans kill more men than bullets." This criticism, however, relates only to the improperly prepared article. To prepare beans, they should be soaked in warm water about twelve hours and then be boiled until they are tender, which will require about two or three hours more. No amount of boiling will soften old beans; such should be soaked twenty-four hours and then crushed and stewed.

It should not be forgotten that neither beans nor peas can be properly cooked in hard water. Where such is the only supply at hand it should be corrected before use, according to the method given elsewhere. The following table shows the average chemical composition of issue beans:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
13.2	22.3	1.8	59.1	1,605

The small white bean is used in our army, it possessing many qualities which render it specially adapted to the military service. It resists weevils and moisture best and stands transportation well. While small beans are preferable, this quality is not so important as uniformity in size, so as to insure evenness of cooking. New beans, if dry, are to be preferred, and can generally be told by their being soft when bitten through. The tendency of beans is to absorb moisture, and if sacked in a damp condition they are liable to become musty. They should be removed from the sacks and exposed to the sun from time to time, this not only keeping them dry but destroying weevils.

Good split peas should be free from hulls or skins and be of a bright orange color. When brown in color, it indicates scorching during the process of kiln-drying. Ordinarily, one part of the dry pea equals, by weight, about four parts of the fresh pea in proteids and carbohydrates. Their richness in nitrogen makes them theoretically valuable as substitutes for meat; but as a matter of fact they are not relished to any extent by troops, who ordinarily make use of them only in soups. Peas are much inferior to beans as a military food—the latter partaking of the nature of a national dish—and can well be dropped from the ration except for field service, when they should be issued in the form of pea-meal to supply the deficiency of protein in the bacon ration. The average chemical composition of dried peas is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
10.8	24.1	1.1	61.5	1,655

Lentils are thought to possess laxative qualities and be more digestible than beans or peas. They are included in the rations of several foreign armies, including that of France. They are not a popular article of diet in this country and are rarely used as food by civilians, a fact which at once shows them to be undesirable for our military service.

Rice.—As an article of diet, rice has the advantage of possessing an extremely digestible starch grain. It is, however, poorer than wheat in protein, fat and salts, and is essentially a carbohydrate food. Alone, it cannot be made into bread, but it is much used in France in connection with wheat flour to make the very white bread which is in request in that country. It is said that during the siege of Santiago the Spanish troops were subsisted on bread largely composed of rice. While rice constitutes so great a proportion of the food of the human race, especially in warm

climates, it is comparatively little employed in the United States. It is included in the ration in the quantity of 1.6 ounces, but is not especially popular with troops; a fact apparently due to the usually improper methods of preparation employed in our service, it being ordinarily insufficiently cooked or else reduced to a paste. Rice should not be cooked by boiling, but be steamed until tender. When boiled, it yields to the water a considerable part of its nitrogenous and mineral constituents, in which it is already naturally deficient. This objection does not apply to the preparation of rice for soups, in which all its extracted matters are ultimately consumed by the soldier.

The characteristics of good rice are semi-transparency, freedom from grit, dust or hulls, and few broken or dead-white grains. Its average chemical composition is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
12.4	7.8	0.4	79.0	1,630

A good, clean, fresh-milled head rice is required for the army. Old rice has a yellow appearance, while the fresh-milled is clean and white. Mustiness is detected by the smell. Storage should be in a cool, dry place, the greatest danger being from weevils and moisture. Rice is the most important constituent of the Japanese army ration, being issued in the amount of thirty-six ounces daily per man, and constitutes the emergency ration in the same service. It also enters into the rations of the German, Austrian and Italian armies. Efforts should be made to popularize its use in our service by giving more attention to the best methods of its preparation.

Hominy.—This is included in the ration in the proportion of 1.6 ounces. It is an article of food much used in the southern states, but it is not popular among the residents of the northern part of this country, from which latter region the military establishment is largely recruited. It is but little used by troops, and there would seem to be no valid reason why hominy should be retained in the ration as long as cornmeal is also issued. The average chemical composition of hominy is as follows:

Water, per cent.	Protein, per cent.	Fats, per cent.	Total carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
11.8	8.3	0.6	79.0	1,650

Hominy should be stored in a cool, dry place. It is likely to harbor weevils in summer and to become musty in warm, moist weather.

Oatmeal.—It would be much to the advantage of troops if hominy were replaced by rolled oatmeal in the ration. The latter is a substance rich in nitrogenous matter and is an excellent food for soldiers at all times. As porridge, which consists simply of the meal well boiled, it admits of various nutritive combinations, and while it lacks adhesiveness for making large loaves it can be readily made into small flat cakes which are very palatable. It is a valuable addition to animal and vegetable broths, and

its issue in the form of gruel, to guards or troops performing heavy fatigue, is much to be recommended.

To cook rolled oatmeal it should be mixed with boiling water and allowed to stand and simmer, without stirring, for twenty minutes. This is practically the only cereal food which can be used with satisfactory results without further cooking. When no fire is available, if mixed with cold water, with a little salt or sugar, and allowed to stand for one or two hours, it makes a palatable, wholesome and nutritious food and drink combined. For this purpose the rolled article is preferable to the steel-cut oatmeal, as the former is already partially cooked by the steaming process required in its preparation. The average chemical composition of steel-cut oatmeal and rolled oatmeal is as follows:

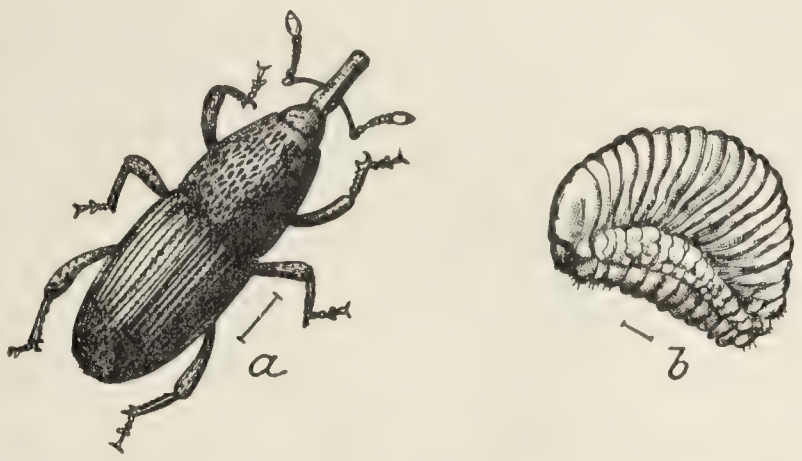


FIG. 91.—Rice Weevil, Calandria oryza. (*a*), Beetle; (*b*), larva. (Much enlarged.)

Article.	Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
Steel-cut oatmeal	7.3	16.1	7.2	67.5	1,860
Rolled oatmeal	7.7	16.7	7.3	66.2	1,850

Oatmeal should be stored in a cool, dry place and not near articles that emit odors. It deteriorates with age and, therefore, the supply should be frequently renewed. Rolled oatmeal appears to keep better than the steel-cut article.

Cornmeal.—This, on account of deficiency in gluten, is not adapted to making raised bread without the admixture of wheat or rye flour. It can readily be made into cakes, or be boiled and fried; containing, as it does, nearly as much protein as wheat flour and much more fat, it stands in a high position as regards alimentary value for the military service. It is a common article of diet in the southern portion of this country, and when well prepared is usually much liked by troops. Its use in our service should be encouraged. Through the mechanical irritation of the intestine by its particles it prevents constipation. This same quality, however, operates against its use during outbreaks of diarrhœa and dysentery. Cornmeal, if kept too long on hand, or if not properly stored or cared for, is liable to become sour. It is also frequently injured by worms, these being of comparatively large size and of repulsive appearance. The average chemical composition of granular and unbolted cornmeal is as follows:

Article.	Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
Granular cornmeal	12.5	9.2	1.9	75.4	1,655
Unbolted cornmeal	10.3	7.5	4.2	65.9	1,545

Dried Fruits.—These are a recent and valuable addition to the food allowance of the soldier, each ten rations including three each of dried apples and apricots and four of prunes. The daily allowance is two ounces. Dried fruits have a special value in connection with the field ration, since they act as correctives to a diet of bacon, hard tack and coffee in preventing constipation. They are also antiscorbutics, and although scurvy could probably never occur in garrison with present food allowances, there is naturally a tendency to it in the field with the above limited diet. Dried fruits, if properly prepared, may be expected to keep a year. They are light and are uninjured by freezing, and when cooked a small quantity of the dried article will make an amount sufficient for many men. The average chemical composition of the dried fruits issued is as follows:

Article.	Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, including fibre, per cent.	Fuel value per pound, Calories.
Apples	28.1	1.6	2.2	66.1	1,350
Apricots	29.4	4.7	1.0	62.5	1,290
Prunes (whole)	19.0	1.8	....	62.2	1,190

Dried fruits should be free from dirt, sticks and worms, and should contain a considerable proportion of sugar. They should not be hard or shrivelled, nor should the taste be musty. Prunes should have a glossy appearance, this disappearing with age. Old and stale prunes are frequently dipped in hot sugar and water; a process which restores the gloss but not the softness and smoothness of the freshly packed fruit. As prunes are not pitted, and as the pits are often as large in the smallest as in the largest prunes, the latter are obviously preferable. Good prunes have a thin, soft, pliable skin and abundance of meat of a rich, delicately sweet flavor.

Fresh fruit, which may be noted in this connection, does not enter into the ration of the soldier; but much is nevertheless consumed by troops, either as individual purchases or provided from company funds. It is ordinarily a valuable addition to the dietary; bananas and grapes being the most important from the standpoint of nutrition, although all are grateful for the vegetable acids which they contain. While sound, ripe fruit which has not been handled is undoubtedly harmless, that which is unripe, decayed or contaminated by uncleanly handling or improper storage is always unwholesome. To avoid outbreaks of intestinal disorders the inspection of fruits offered for sale to troops, particularly by hucksters in the vicinity of camps, should be rigid. When intestinal disease is prevalent among troops, the sale of fruit, from unknown sources and by irresponsible parties, should be prohibited in camp or garrison. Fresh fruit, when supplied from the company fund, should preferably be eaten by the men only after cooking, since by this way the dangers attaching to possibly unripe or contaminated fruit are avoided.

THE SUGAR, COFFEE AND CONDIMENT COMPONENTS.

Sugar.—The authorized daily allowance of sugar is two and two-fifths ounces, a quantity which for ordinary use appears to be barely sufficient. Brown or issue sugar contains more water than the white, the amount varying from 4 per cent. in the better kinds to 10 per cent. in the coarse varieties. Its color is due to invert sugar, of which there is 4 or 5 per cent. present. The average chemical analysis of brown sugar shows 95 per cent. carbohydrates, with a fuel value of 1,765 Calories per pound; white sugar contains 100 per cent. of carbohydrates and has a fuel value of 1,860 Calories per pound. The whiter the sample, the less usually is the percentage of water. The unpurified sugars contain nitrogenous matters which decompose, and a sort of fermentation often occurs. Mites are often found in such sugar, while fungi are very frequently present.

When of good quality, sugar should be more or less white, crystalline, not evidently moist to the touch, and should dissolve entirely in water—or leave merely small fragments, which, on examination with the microscope, will often be found to be bits of cane. In this country sugar is rarely adulterated, its present low price protecting it from such frauds. Out of five hundred samples of sugar lately examined by the Department of Agriculture, not one was found to be adulterated. Sugar being completely soluble in water, the presence of adulterants of an earthy nature is readily determined from the residue left after such solution.

It should not be forgotten that cane sugar may be converted into dextrose, a much less sweet substance, as a result of the change known as inversion, which takes place when cane sugar is made to unite chemically with water, as by boiling with an acid. Cane sugar in this case splits up into a mixture of dextrose and levulose, known as invert sugar. Company cooks should be instructed that more sugar is necessary in sweetening acid fruits if it is heated with them from the first than if it be added when the cooking is completed. This is because some of the cane sugar, acted on by the heat and acid, has been changed to other bodies which are less sweet.

The great value of sugar in increasing the ability to perform work and lessening or delaying fatigue has but recently been recognized. Much work on this subject has been lately done, and the results all point to the efficiency of sugar in this respect. Harley found that when nine ounces of sugar were added to a meagre diet, the gain in muscle power was considerable. The effect, though felt one-half hour after eating, was at its height in two hours. Very interesting also was the effect of sugar in delaying the natural coming on of fatigue, which had been found to occur between 5 and 7 P.M. If three or four ounces of sugar were taken a short time before this hour, fatigue did not appear and work went on as usual. Schumberg, experimenting on this subject for the Prussian war office, says: "The practical conclusion to be drawn is that sugar in small doses is well adapted to help men to perform extraordinary muscular labor." If the sugar is to be taken in solid form he recommends chocolate as the best

medium. The application of these results to the food of soldiers who may be called upon for extraordinary exertion in marching or fighting is very evident; and in 1898 a practical test as to the value of sugar was made with soldiers of the German army during the autumn manœuvers, the observation extending over thirty-eight days. A number of men were given ten lumps (70 gm. or about one-sixth pound) of sugar daily, and were compared in various ways with men performing the same amount of work in marching and drilling, but whose food contained little or no sugar. The results were in every way to the advantage of the men using sugar. The sugar was relished during the whole time. On long marches it appeased hunger and mitigated thirst; a feeling of refreshment followed which helped the tired man on his way, and none of the soldiers allowed sugar were at any time overcome by exhaustion. It was found that both their pulse-rate and breathing were less affected by exertion than was the case with the men consuming no sugar. On the basis of these results the medical officer making the investigation recommended that the sugar ration for soldiers be raised to 60 gm. daily, and that it be furnished as sugar for coffee and in sweetened food, preserves or honey. The influence of sugar on muscle exhaustion was further investigated in 1899 by Prantner and Stowasser. Before performing muscular work, 30 gm. of grape sugar were administered in weak tea. In control experiments an amount of dulcin equalling the sugar in sweetness was taken. The investigators did not know whether they had consumed sugar or dulcin. More work was performed when sugar was consumed than in the other cases. When sugar was added to a diet which sufficed for nitrogenous equilibrium, the amount of nitrogen excreted in the urine was diminished. In the opinion of these observers sugar is useful as a muscle food for those who have a single muscular task to perform, rather than for those who are engaged in constant, though severe, manual labor. Within the past two years, according to Abel, sugar has been much used in the training diet of athletes, not only apparently increasing muscular power and endurance but preventing staleness from over-training. During the recent war in South Africa the British soldier received a ration of jam, four ounces three times weekly, which was said to be much appreciated. In view of these facts it is certainly much to be regretted that sugar has been omitted from the established emergency ration, since the evidence is conclusive in showing the special service rendered by sugar under just the conditions in which this special ration would be employed. There can be no doubt that about three ounces of sugar, combined with chocolate, would be a valuable addition to the emergency ration.

Molasses and Cane Syrup.—These are each issued, in lieu of sugar, in the proportion of two gallons per hundred rations. They are not much liked by troops and are rarely drawn. As a substitute for sugar the ration of molasses or cane syrup is quite inferior. Analysis gives to molasses a composition made up of 25.1 per cent. water, 2.4 per cent. nitrogenous matter (probably not protein), and 69.3 per cent. carbohydrates; the fuel value per pound is 1,290 Calories. The chemical composition of cane syrup varies little from that of molasses.

Saccharin.—In this place it is convenient to mention saccharin—orthobenzoic sulphinide—which has appeared in the trade as a white in-

odorous powder, three hundred times as sweet as cane sugar. Pure saccharin is soluble in water, one part in two hundred and sixty, and has a faintly acid reaction; but lately an alkaline salt has been introduced which is more readily dissolved. Its flavor is slightly aromatic and its after-taste irritating only when the powder itself, or a concentrated solution, is tasted; dilute solutions have a purely sweet flavor. As one part of saccharin is sufficient to give five hundred parts of starch sugar the same sweetening power as an equal part of cane sugar, it is likely that adulterations of this character will be made. The detection of saccharin may be effected by extracting the dried substance with anhydrous ether. If the evaporated residue have a sweet taste saccharin is present, since all sugars and glycerin are insoluble in ether. According to the experiments of all observers, saccharin is non-poisonous, even in continuously large doses. Since, however, it has no nutritive or stimulant value, its substitution for a carbohydrate in the ration is quite inadvisable and against the interests of the service. The alleged antiseptic properties of saccharin have, as a matter of fact, no practical importance.

Coffee.—The allowance of coffee in the ration is one and three-fifths ounces when in the green state, and one and seven twenty-fifths ounces when roasted; this difference representing the average loss of water during roasting. This allowance appears to be sufficient, especially since soldiers generally prefer to use their coffee in an extremely weak infusion. Its employment in this way should be encouraged, as it insures the use of a sterile drink. In winter the heat given out by steaming hot coffee is valuable and permits of a certain quantity of food being used for purposes of energy, which otherwise would be devoted to the maintenance of body temperature. In summer, coffee supplies in a safe form the fluid necessary in the production of perspiration, and when carried in the canteen on the march it proves an efficient substitute for water and is valuable for its directly stimulating properties. As an article of the ration it is indispensable, and in our service is much preferred by the men to tea.

When supplied in the fresh bean, coffee keeps well and is not subjected to adulteration except in rare cases. Hence it is in this form that it should be purchased for army use. Sometimes coffee contains black, mouldy and worm-eaten kernels, and such samples should obviously be rejected. In the ground and roasted state it is frequently adulterated with chicory, the dried and powdered root of the wild endive; this adulteration is not injurious to health and the flavor of coffee sophisticated in this manner is even preferred by some. In the Belgian army it is even intentionally mixed, in equal parts, with the coffee to be issued. The Government, however, should receive the pure article for which it pays a full price, and the soldier is entitled to the full benefit of the stimulant qualities—so valuable in the field—present in coffee and wanting in chicory. A number of tests have been proposed for the detection of the latter substance; of these the fact that when thrown into water, chicory rapidly sinks and colors the liquid brown, while coffee floats and does not leave any color, may be used to advantage by the sanitary officer. If additional evidence be required, the microscope may be used, the characteristic cells and dotted ducts of chicory being at once apparent, while the long cells of

the testa of the coffee berry are marked and the interior contains an irregular areolar tissue containing light or dark yellow angular masses and oil globules. The appearance of coffee is not necessarily a reliable index of its quality, and a sample should always be roasted, ground and made into an infusion. The latter should be tested for odor as soon as practicable and by taste as soon as cool enough for the purpose. After standing a little while, the odor and taste should again be noted. This test is best made comparative by making a control experiment at the same time with coffee of known good quality.

Care should be taken that the coffee beans in a sample are of the same size; since, in roasting, the small grains may be carbonized before the larger ones become sufficiently parched. The extent to which coffee is roasted materially influences the amount of matter susceptible of extraction. When roasted to a reddish-brown color and subjected to boiling water, Pavy found that twenty-five per cent. could be extracted—as against nineteen per cent. when the roasting was carried on to a chestnut-brown color. All coffees improve with age and should be at least one year old before being used. They require dry, well-ventilated storage, and, as they readily absorb odors, should not be placed in proximity to articles possessing a strong odor. When ground, coffee does not keep well, especially in hot, moist climates. Ground coffee should always be put up in tight containers. When coffee has been long roasted and is hence a bit stale, it is said that it can be freshened and much improved in character by heating before grinding.

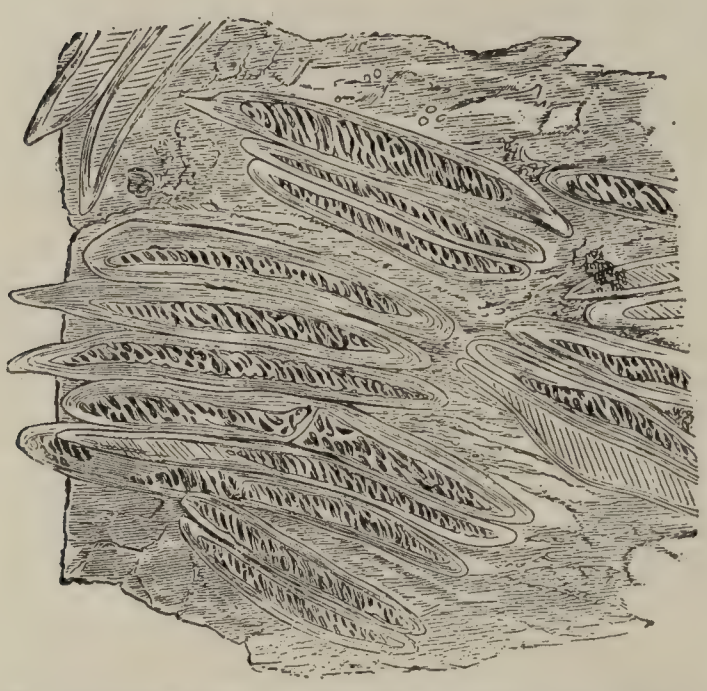


FIG. 92.—Section of Coffee Bean, Enlarged, Showing long cells of the testa in the berry. (After Notter and Firth.)

In the field the disadvantages of coffee are its bulk and the ease with which the roasted and ground berry is lost from the haversack and parts with its aromatic constituents. The issue of the green berry in the field, as was the case during the siege of Santiago, is often of almost no utility; since where the soldier is provided merely with his mess kit the proper roasting and grinding of the berries is practically beyond his powers.

As prepared in our service, coffee is often not an infusion but an overboiled decoction, and sometimes contains considerable charcoal due to carelessness in roasting. Some company cooks habitually boil their coffee and leave it on the fire for several hours, a practice destructive to its good qualities. In cool climates it is of advantage to moisten the ground coffee and let it stand over night before infusing. In this way the full quality of the berry is said to be extracted to best advantage. For the preparation of coffee an excellent form of apparatus is used in the French army which should be adopted in our service. By its use it is said to be practically impossible to prepare coffee of any but excellent quality. As shown in the accompanying illustration, the water in the lower reservoir of the ap-

paratus is forced up through the central pipe and sprayed over the ground coffee resting on the upper perforated shelf; it then trickles through the coffee into the upper reservoir and is returned to the lower reservoir — to replace the water forced out by ebullition—by a pipe discharging near the bottom. While boiling is maintained in the apparatus the percolation through the ground coffee is thus continuous. By this method the necessity of clarifying with egg shells, fish skin, cold water or other means is avoided. It is sometimes of advantage, with ordinary pots, to place the ground coffee in a thin muslin bag before adding to the water.

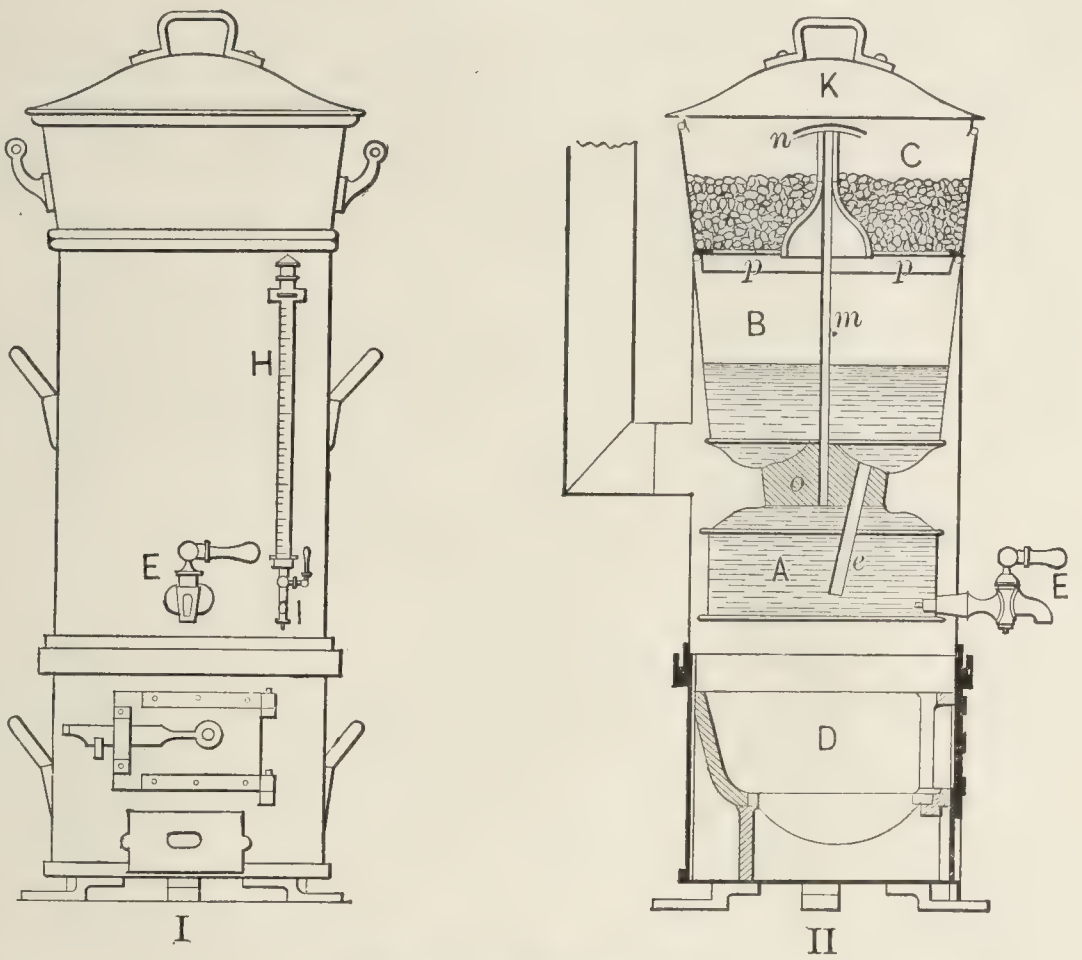


FIG. 93.—Coffee Percolator.

Tea.—As issued to troops, tea leaves are curled; but they assume their original appearance when placed in hot water, and show their characteristic shape and structure. The border of the leaf is serrated nearly, though not quite, to the stalk; the primary veins run out from the mid-rib nearly to the border and then turn in, so that a distinct space is left between them and the border. The leaf may vary in point of size and shape, being sometimes broader and sometimes long and narrow. In general, the larger the leaf the weaker will be the infusion and the less the value. A knowledge of the structure of the tea leaf is of importance, since a common method of adulteration consists in the addition of the leaves of the aloe and willow, which have a superficial resemblance to those of the tea plant. Such adulteration naturally alters the flavor of the tea. A common method of falsification, also, consists in the addition of old or exhausted tea leaves, these being given a natural color by artificial means and then dried. Such coloration, which is produced by several methods, gives rise to a dirty scum which forms on the surface of the infusion and often imparts a somewhat greasy appearance and feeling to the leaves. If an infusion of such tea be strained through cloth, some of the coloring matter will be retained on the fabric. The total soluble matters obtain-

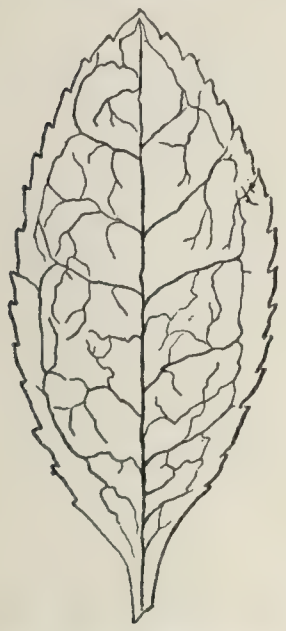


FIG. 94.—Tea Leaf. (After Notter and Firth.)

able from tea are a ready and convenient index of its quality. In general, with a good tea a weighed quantity infused with an excess of distilled water should yield, on evaporation of the infusion, a residue possessing thirty per cent. of the weight of the quantity of the tea used. Sand and magnetic oxide of iron are sometimes added to tea to increase its weight. These substances can be readily detected by the microscope. Like coffee, the quality of tea can often best be determined by its preparation. The buyers of tea appear to depend especially on the taste and smell of the infusion.

In general, tea fit for army use should not be too much broken up or mixed with dirt. Spread out, the leaves should not be all large, thick, dark and old, but some should be small and young. In the best tea there will always be a good deal of the stalk and some remains of the flower. In old tea much of the ethereal oil has evaporated and the characteristic aroma is less marked.

The allowance of tea, either green or black, is fixed at eight twenty-fifths of an ounce. This quantity is quite sufficient to meet the needs of our service. As compared with coffee, tea has practically the same physiological action but its flavor is by no means as acceptable to most soldiers. Tea lends itself admirably to campaign uses, its weight being about one-sixth that of coffee and it having the further advantage of small bulk. A water-proof covering is necessary for its carriage in the field, and for this purpose tea is much used in the German service in small tablets, wrapped in paraffined paper. When improperly made or allowed to stand, tea becomes bitter from the tannin which it contains; and the latter substance also attacks iron. When carried in the canteen this action is marked. Tea is best made in scrupulously clean vessels with no exposed iron, and should be prepared by pouring boiling water on the leaves and letting the whole steep for a few minutes in a covered utensil. If hard water must be used this fault should first be corrected by the method given elsewhere. Besides having the sanitary advantage of boiled water, tea masks many of the offensive qualities of water containing suspended and decomposing organic matters and its use for this special purpose may at times be of advantage. Tea is generally preferred to coffee by Arctic explorers, and by hunters and trappers in the northwest. It is much used in the Russian army, practically replacing coffee in certain military districts, and is also largely employed in the British army. In the expedition against the Ashantis in 1876 the experiment was successfully tried of substituting tea for the spirit ration allowed the British soldier. In the French service tea is used only in the colonies; the soldiers, according to Laveran, ordinarily regarding it more as a medicament than a beverage.

Chocolate.—This is a substance which, while too costly for garrison use, may with advantage be supplied, in the proportion of two or three ounces, in the field ration—serving as required either as a food or beverage. It contains about thirteen per cent. of protein, fifty per cent. of fat and thirty per cent. of carbohydrates, and has a force value per pound of nearly three thousand Calories, or almost three times that of fresh beef. Its palatability and keeping qualities are admirable and it is very compact and portable, thus fulfilling all the requirements of a military food. Unlike tea and coffee, its stimulant properties are small.

Chocolate is largely adulterated. When of good quality it should be compact, brittle and of a reddish-brown color. It should break in the bar under only a moderate strain and the fracture should be clean and show a fine grain. When worked into a paste it should be perfectly homogeneous. It should melt easily in the mouth, leaving no residuum, and should completely dissolve in milk or water. Chocolate forms the basis of part of the English emergency ration; and as cocca, which is chocolate with a considerable proportion of the fat removed, it is commonly used in the same army. Large shipments of chocolate were recently made to the British troops operating against the Boers in South Africa. Chocolate is not a common beverage in this country, and for long-continued use would undoubtedly become somewhat distasteful to troops and inferior to coffee. For field use, however, it has everything to commend it, and its great palatability would render it at once a pleasant as well as nutritively valuable component of the ration.

Salt.—The use of salt in the organism is extremely important; about an ounce of saline substances being necessary for the proper maintenance of nutrition. The chlorides generally keep in solution the globulins of the blood and other fluids, while at the same time they are the sources of the hydrochloric acid of the gastric juice and materially aid in the solution of albumen. The sodium salts are especially necessary in a vegetable diet to compensate for the quantity of potash salts contained in vegetable material. The complete withholding of ordinary salt from the food leads to rapid disease and even death. Its partial deprivation caused much suffering among the French troops during the siege of Metz, inducing a peculiar lassitude and muscular weakness. Sodium chloride is a constituent of all animal tissues, and this fact was formerly utilized by the Indians, who, in the absence of salt, were accustomed to retain the water in which meat had been boiled and use it in the preparation of other meat. Considerable sodium chloride is dissolved out of meat by boiling, and water repeatedly used for this purpose ultimately acquires a a distinctly saline taste.

The culinary use of salt to render food more palatable is generally in excess of the requirements of the system, and in such excess it must be considered as a condiment. The failing of nearly all cooks is to use salt and pepper in excessive quantity. These articles must always be within reach that each man may flavor his food to his taste, and cooks should be instructed to use the minimum amount of seasoning. The present allowance of salt, sixteen twenty-fifths of an ounce—together with the salt present in the bacon and pork ration—amply suffices for the needs of the soldier.

In character, salt should be clean and free from foreign matter. Dissolved, it should leave no earthy residue. The cheapness of salt offers no inducement for its adulteration.

Pepper.—Black pepper is issued in the proportion of four ounces per one hundred rations. This quantity appears to be sufficient, as it is a substance by no means necessary to the welfare of the organism and is employed only to give a zest to food. It owes its value as a condiment to the aromatic oil which it contains. This oil is antiseptic in quality and undoubtedly has a certain influence in retarding acid fermentation in the

digestive tract. Pepper also promotes the flow of digestive juices and stimulates peristaltic action of the intestines.

The microscopic characters of pepper are somewhat complicated; there being a husk composed of four or five layers of cells and a central portion. The cortex has extremely elongated cells, placed vertically and provided with a central cavity, from which lines radiate toward the circumference. Then come strata of angular cells, which toward the interior are larger and are filled with oil. The third layer is composed of woody fibre and spiral cells. The fourth layer is made up of large cells, which toward the interior become smaller and of a deep red color; these contain most of the essential oil of the pepper. The central part of the berry is composed of large angular cells, about twice as long as broad. Steeped in water, some of these cells become yellow while others remain colorless.

Pepper is one of the most adulterated articles on the market. Linseed, mustard husks, wheat and pea flour and ground rice are often added; the character of these substances can be determined by the microscope. Pepper is also largely adulterated with husks, ground cocoanut shell and mineral substances. The latter can be separated by shaking with chloroform. The active principles of pepper reduce Fehling's solution, and no pure pepper should give less than fifty per cent. of reducing sugar on the ash-free substance; cocoanut shell adulterations usually give about half that quantity. If the powder be covered with pure hydrochloric acid the true pepper grains become intensely yellow, and from these the other substances can be picked out.

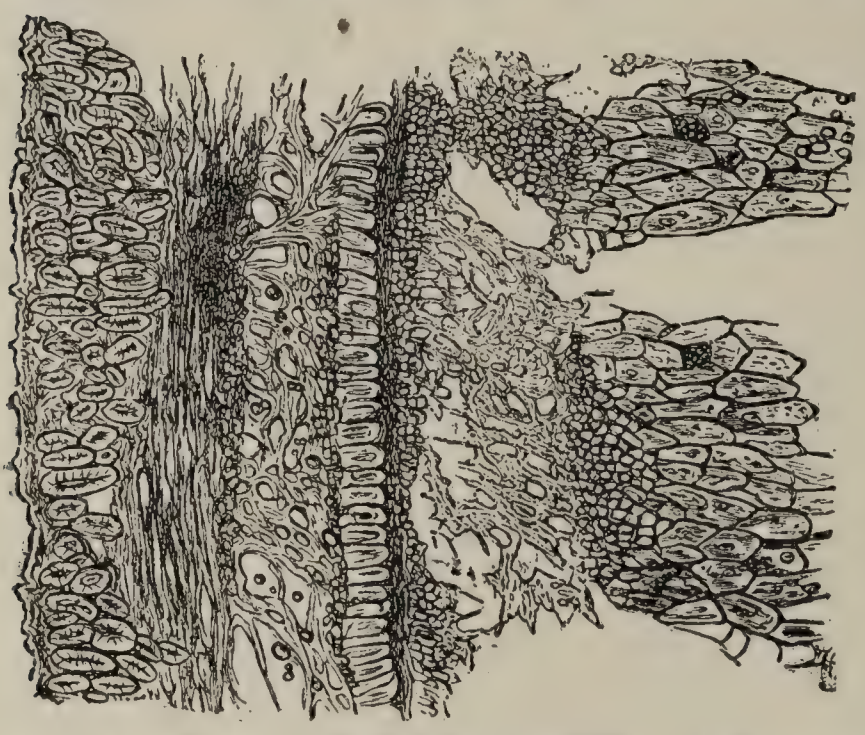


FIG. 95.—Section of Pepper Berry, Enlarged. (After Notter and Firth.)

Vinegar.—The vegetable acids are directly represented in the ration by vinegar, the allowance being one gallon per hundred rations. This quantity, though not large, is rarely consumed, and can with advantage be diminished by one-half and replaced by an equivalent quantity of pickled vegetables, such as cucumbers, onions or tomatoes. Vinegar is a valuable antiscorbutic and its use in any form should be encouraged.

For army use cider vinegar is preferable, and this should contain about five per cent. of acetic acid. The quantity of this acid present may be readily determined by the sanitary officer by taking the specific gravity, the variation ranging as follows:

Specific gravity.	Per cent. of acetic acid.	Specific gravity.	Per cent. of acetic acid.	Specific gravity.	Per cent. of acetic acid.	Specific gravity.	Per cent. of acetic acid.
1,001	1	1,004	3	1,007	5	1,010	7
1,002	2	1,005	4	1,008	6	1,012	8

In addition to sophistication with water, vinegar is not infrequently adulterated with mineral and pyroligneous acids. Usually sulphuric acid is added; this must be determined with care, as the addition of water may have introduced sulphates. The test consists in adding hydrochloric acid and barium chloride to the vinegar; the resulting sulphate of barium, dried, weighed and multiplied by .412 gives the weight of the sulphuric acid. The occurrence of hydrochloric acid is readily determined by adding a solution of silver nitrate to the vinegar, with resulting formation of white silver chloride. Nitric acid is shown by the development of a red color on the addition of a few drops of strong sulphuric acid and brucine. Pyroligneous acid may be recognized by distilling the vinegar and re-distilling the distillate; the residue has the odor of pyroligneous acid. Vinegar is also adulterated by many other substances, but these will rarely come to the attention of the military sanitarian. In the examination of foods by the Massachusetts Board of Health fifty-seven per cent. of all specimens of vinegar examined were found to be adulterated. In many vinegars, especially the weaker kinds, the minute vinegar eels, Anguillula oxyphila, will be found in great numbers. Beyond rendering the vinegar somewhat disgusting in appearance they are not known to exert any prejudicial effect. They are readily destroyed by heating to the boiling-point.

IV.

EMERGENCY OR RESERVE RATIONS.

General Considerations.—Celerity of movement is a matter of prime importance in modern warfare. Sufficient facilities for the proper transportation of supplies being often not available, or if available serving merely to hamper and delay troops, the question of the concentration of the ration to such a degree as to enable the soldier to carry a sufficient supply of food, and thus operate without transportation, for limited periods, at once presents itself. To this end much thought and research have been devoted—especially since the results attributed to the use of "Erbswurst" during the Franco-Prussian War—but the preparation of an emergency food, in all respects satisfactory, can scarcely be considered to have as yet been accomplished. Much, however, has been done, and a vast number of preparations of greater or less value for military use, some of them constituting the so-called "iron rations" of various armies, are now on the market. Among these may be mentioned the various meat, vegetable and pea sausages, the meat powders, meat biscuits, concentrated soups, meat extracts and different compound rations made up of two or more preserved food-stuffs.

As to the special qualities which should be present in the emergency ration, it should be noted that such a ration must often be carried by the soldier for continued periods, and, as the military conditions under which its employment would be authorized are those in which mobility is of prime importance, the first objective in its construction is to provide the greatest food value in the least possible bulk and weight. At the same time a too radical departure from the accustomed food of the soldier cannot be made, lest the digestive system be deranged by the sudden

change—and this at a time when the physical efficiency of each man is of the highest importance. The keeping qualities required of an emergency ration place further limitation on its composition; and a certain variety should be possible, not only in material but in manner of preparation, as sameness soon becomes distasteful. It must be palatable, since if it be disliked by troops it will be wasted and its theoretical value as food largely nullified. To this end a certain amount of condiments should enter into its composition; and since the occasion in which its use is authorized will usually be accompanied by great exertion and fatigue, it should preferably possess not only nutritive but somewhat stimulant properties. It is essential that a fair proportion of the ration should be in a solid form, so that a certain amount of mastication is required and an undigested residue is left to keep the intestines operative through the mechanical stimulus which it provides. It is also necessary that the emergency ration should be a cooked, dry preparation, which can quickly be made into a soup or stew—or which, in the face of the enemy or the absence of fire, may be eaten cold, with or without the admixture of water. The latter quality is one too often disregarded. The addition of water to such condensed food has the advantage of giving an increased bulk which distends the stomach and gives a feeling of satisfaction, while at the same time it promotes digestion. The emergency ration should as far as possible be eaten hot, since heated foods are comforting and stimulating in conditions of exhaustion and there is also an actual economy of food where its temperature has been raised. This, though so slight as to be ordinarily neglected, becomes of importance where foods are restricted in quantity.

An emergency ration need not necessarily contain the several nutritive principles in the quantities and proportion necessary for the maintenance of life and health during an indefinite period. It should, however, possess a relatively high force-value and contain an amount of reparative material sufficient to prevent undue waste in the body tissues during the short time in which such a ration should be employed. Any deficiency in the carbohydrates—which should be the nutritive principle to be first reduced—may be to a certain extent counterbalanced by the higher potential value of the fatty element present, not only in the ration but within the organism of the consumer. The fatty principle, however, cannot be advantageously increased beyond a certain point, nor can it take the place of proteid in the repair of the muscular system; and the latter, if called on to excess for the nitrogen necessary for elimination, ultimately becomes enfeebled.

While reduction in bulk and weight is desirable, there is a limit, however, to which this decrease can be carried out; and scarcely more than the removal of an excess of water and a considerable part of the indigestible material is possible. In practice, the dehydration and compression commonly produced for the sake of concentration appear to affect the alimentary value of the substances concerned by influencing their digestibility and readiness of assimilation. This is especially observed in compressed and desiccated vegetable material—and a sudden change to this class of diet will exercise considerable influence on the production of hunger, indigestion and intestinal troubles. With regard to the use of foods concentrated beyond a certain point, it must be admitted that the stomach is

constructed with a certain capacity for food which cannot be disregarded in favor of any chemical formula which human ingenuity can create or theoretical reasoning devise. Each of the varied and subtle processes of digestion must necessarily adapt themselves to the construction and functions of an organ which has a vital as well as a chemical duty to perform. No prepared or concentrated food can relieve the stomach of any or all of its activities in that gradual conversion of a legitimate quantity and quality of food which constitutes the normal and perfect digestion; and the stomach must be properly distended with food of a sufficiently bulky character, else its most important function is hampered. In concentrated and chemically prepared foods, sufficient importance does not seem to be attached to those portions which are normally passed off with the excretions. Such as are undigested and indigestible are generally regarded as a direct loss, yet all these fulfil very important purposes. Something more is required than complete digestibility and power of absorption in order to gain a full physical effect and retain health in a normal condition.

Regarding the total weight of an emergency ration, it has been stated by Parkes that no great loss of body-weight or impairment of health may be expected to occur with a minimum daily allowance of eleven ounces of water-free food and a maximum time of one week. This statement may be considered as approximately correct, provided the food is properly proportioned as to its nutritive principles, troops are fully fed before being placed on such a restricted ration, and are subsequently allowed rest and a generous dietary for the replenishment of the systemic losses. Officers should appreciate that, while supplying a certain amount of force, concentrated foods are ordinarily not sufficient to repair but merely retard tissue waste, and that, like high explosives, there are strict limits to their field of usefulness. A practical objection to prepared foods, as seen in many of the commercial emergency foods, is the ease with which adulteration and fraud can be practised. The quality of food can be readily determined if seen in the natural state, but when the article is ground up and mixed with other material no such safeguard exists. This objection, however, is somewhat lessened by the fact that prepared foods are intended for occasional use only—and it may probably be made to disappear under a rigorous system of inspection and analysis.

In most foreign services one or more emergency or reserve rations is habitually carried in peace or war in the equipment of the soldier—he being thus accustomed to its appearance and weight. This would seem to entail a useless expenditure of energy, and the far better plan for our own service consists in issuing these rations to troops only when there is reason to believe that they may soon be required. The portions in which the emergency ration is issued should never be larger than the allowance for one day; since a package, once broken, soon deteriorates in quality and becomes unfit for use. The various components, especially the meat, should be kept separate. The emergency ration should not be used until all other sources of supply fail, and then only on orders from high authority. If possible, it should not be used alone but should be supplemented by any other articles of food available. Once used, it should be replaced as soon as possible if the circumstances indicate that it may be again required. Its maintenance while in the care of the soldier should be insured

by frequent inspection, and its unauthorized use should be punished by disciplinary measures and a proper stoppage against the pay of the offender. On the whole, not more than three or four of these rations should ever be issued at any one time, since they are at best but makeshifts and by their continued use the organism suffers. Ordinarily an unforeseen emergency, where the use of such foods becomes desirable, will last for but a few hours.

The United States Army Emergency Ration.—This ration was elaborated by a board of officers several years since, acting largely on the recommendations of similar and subordinate boards convened for the same purpose in each military department. Its composition and nutritive value is as follows:

Articles.	Quantity in ounces.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.
Hard bread	16	70.76	5.89	332.94	1,712
Bacon	10	24.94	218.14	.....	2,030
Pea-meal	4	24.94	2.25	59.84	368
Coffee, roasted and ground, with four grains of saccharin	2				
Or tea, with four grains of saccharin	.5				
Salt	.64				
Pepper	.04				
Tobacco	.5				
Total	33.68	120.64	226.28	392.78	4,110

The force-value of this ration is high and the available nitrogen is sufficient for the needs of hard labor. Divided in half, it practically furnishes the subsistence diet of physiologists. The components of this ration are put up in small individual packages; the bacon being wrapped in tough paraffin paper, the hard bread in grease-proof coverings and the pea-meal in cylindrical packages. The other articles are put up in small water-proof packets. It is officially enjoined that this ration shall be resorted to only on occasions arising in active operations when the use of the regular ration may be impracticable; that although it may be used in half allowance, it will not be so used except in case of overruling necessity and never for a longer period than ten days; also that not more than five of these rations are to be carried on the person at one time.

This emergency ration was subjected to a practical trial in the field, in 1897, by a troop of cavalry; the command having been given a preliminary march of two days on full rations. The men were then weighed and proceeded on a ten days' march, averaging about twenty-one miles daily. The route was through a totally uninhabited country where no food could be obtained from outside sources. Five full emergency rations were issued to each man at the start, and these were made to do for the full ten days. Careful records kept by Smart showed that during the ten days there was an average loss of weight amounting to 2.935 pounds per man; but the loss was not evenly distributed, some men maintaining their original weight while five men even gained in weight. The losses in weight were greater among the younger soldiers and those of heavier build. The muscular

strength of the command, as shown by the dynamometer, increased an average of twenty-four pounds per man. A control experiment was made at the same time by an officer and nine men, who were allowed to eat all they desired of the regular established ration. This detachment marched parallel to the route of the larger command at a distance of about ten miles. Of this smaller detachment the average loss in weight amounted to 1.35 pounds per man; the average strength, as shown by the dynamometer, increased by 32.8 pounds. From the above practical test of its value the sufficiency of half portions of the emergency ration, during the period of ten days, may be regarded as established.

This ration has the important advantage of containing practically no articles except those to the use of which the soldier is habituated, and which are always available or kept on hand by the Subsistence Department. It contains no compound prepared foods and its proper quality is readily assured. It requires no special machinery or plant for its manufacture and is also comparatively light. On the other hand, it possesses certain positive disadvantages. It is somewhat heavier than the emergency rations used in foreign armies and the bulk of the hard bread makes the carriage of five full rations on the person of the infantryman a matter of some difficulty. Further, only one article of this ration—the hard bread—can be eaten without further preparation by fire, and this may be a serious defect under many conditions. As already noted, sugar possesses a high value in the prevention of fatigue and the creation of energy. It should by all means replace saccharin in the emergency ration, preferably in the amount of two or three ounces. Sweetened chocolate might also be issued alternatively as well as the tea and coffee. Since half portions of the authorized emergency ration are shown to be sufficient for subsistence, it is difficult to understand why this ration should remain in its present quantity, which is practically a double allowance. It would certainly appear to be of advantage to make the individual ration smaller. For the above reason it would seem that this ration, while excellent in nearly all respects, might justly be regarded rather as a reserve than an emergency ration in the sense that this term is applied abroad. As yet none of these rations have been issued and used in actual service.

Since the chief value of this ration as regards energy is due to the high proportion of fat it contains, it is obvious that the method of preparation exerts a marked effect upon the quantity of nutritive material consumed by the soldier. When food is abundant such a loss may be of no particular importance; but it is intended that every portion of an emergency food shall be devoted to purposes of nutrition and no provision is made for wastage. When the bacon is fried to a crisp, the meat is reduced about two-thirds in weight and the fat fried out is ordinarily lost. If softened hard bread be fried in the melted bacon fat a greater proportion is saved, but the resulting combination is indigestible. The best method of preparing the bacon undoubtedly consists in chopping it into small fragments and boiling it in the pea soup. In this way there is no wastage.

With the idea of avoiding the several practical faults of the emergency ration just described, a board of officers has recently devoted much time and effort toward devising a combination of foods more adopted to emergency purposes. Their proposed ration, at the present writing, is being

given a trial by troops in the west. It is understood to be composed of two parts. The first consists of parched wheat, mixed with beef which has previously been dried in thin strips and then crushed into small fragments. A little seasoning is added. The mixture is very palatable and makes an excellent soup; though it may be eaten without any cooking, if necessary. The second portion of the ration consists of sweetened chocolate, which may obviously be used as either a food or beverage. This ration, which it is proposed to pack in an oval tin having two compartments, will furnish 127 gm. of protein and has a fuel-value of about eighteen hundred Calories. The amount of fat present is small, and the fuel-value of the ration, for its weight and bulk, suffers greatly thereby. Much of the protein is of vegetable origin and is hence less readily digestible. It does not appear that this ration possesses any special virtues over a number of excellent concentrated foods now on the market. In its proximate composition and fuel-value—as is shown by a subsequent table—it is very much inferior to the pemmican and cocoa-paste emergency ration of the British army, to some of the Bovril emergency foods and to certain other preparations.

Emergency Rations of Foreign Armies.—Experiments are still in progress in the British army with reference to a suitable emergency ration. Until 1896, this ration merely consisted of a couple of ordinary cooked rations. Recently a compressed vegetable ration of unknown composition, used with compressed tinned beef, has been tried. Bovril cartridges have also been tested, and it is said that a considerable number of the so-called "Standard Emergency Ration," put up by a firm in this country, have been used by the British troops in South Africa. The custom is to allow makers and inventors of prepared military foods to furnish samples of their products for trial, and officers and men are also authorized to make experimental use of such articles at their own expense. Pemmican has been much used by British troops in the field in India, Africa and elsewhere. This is a preparation of beef, with fat and salt. It is supplied in flattened tins about four and one-half inches long, weighing eight ounces. The method of manufacture is a trade secret. It can be eaten without any preparation, or can be made into beef tea, hash or soup by boiling with vegetables. It is said that it will keep sound for years, even after free exposure to the air. As shown by analysis, this preparation gives sufficient salts, protein and fats for emergency use. It contains no carbohydrates, and these are supplied in another part of the official emergency ration. This second portion consists of cocoa and honey, in another compartment of the can containing the pemmican. The net weight of the pemmican and cocoa paste is about nine ounces. With this ration, eight ounces of hard bread are usually issued for use in an emergency.

According to Woodruff, the French soldier when in the field carries two days' reserve rations, which he is not allowed to consume except by order from higher authority. The components of this ration and their approximate weights in ounces are as follows:

Hard bread	42	ounces.
Rice	7	"
Preserved meat	17	"

Condensed soup	1⅔ ounces.
Salt	1⅓ "
Sugar	2 "
Roasted coffee	1⅔ "

The hard bread has presumably been replaced by the new war bread, but whether in the same amount is not known. The above weighs four pounds, ten ounces; the daily allowance being one-half of this quantity. This is an unusually generous diet for emergency use. As in most foreign rations, the fats appear to be notably deficient. These rations are put up in two small sacks, so that they may be kept separate from the other rations. As the smallest tin of meat issued holds four field rations, one of these boxes is given to every other man.

The German foot-soldier carries an emergency ration sufficient for three days. This is not drawn upon except in cases of urgent necessity or when it can be at once replaced by a fresh supply. The cavalry soldier carries but one day's extra rations. The infantry emergency ration is as follows:

Hard bread	17.5 ounces.
Preserved meat	7 "
Or bacon	6 "
Rice	4.5 "
Or meal	6.75 "
Coffee	.875 ounce
Salt	.875 "

The above weighs two pounds, four ounces. The daily amount is but twelve ounces of water-free food, which is about twenty per cent. less than in our own emergency ration. It is undoubtedly a meagre diet when taken by itself, but it is intended for use during short periods only and is probably also regarded as a base to which the food usually to be obtained in a densely populated country, like Europe, could be added. It is said that a modification of this ration, containing two pounds of hard bread, one pound of preserved meat and one pound of tinned preserved peas, the latter containing considerable fat, is now being tried.

The Austrian army has several emergency rations. Of these, one is stated by Viry to contain 400 gm. of compressed bread, 200 gm. of preserved meat and vegetables, 25 gm. of salt, and coffee and sugar in tablets. Another emergency ration used in the Austrian service is composed as follows:

Hard bread	17.6 ounces.
Preserved meat	7 "
Preserved soup	1.3 "
Salt	2 "

Each of these rations is obviously of extremely low nutritive value and suitable for use during brief periods only.

Switzerland has an emergency consisting of 8.75 ounces (250 gm.) preserved meat, 50 biscuits (5 gm. each), weighing 8.75 ounces (250 gm.), and 3.5 ounces (100 gm.) of compressed pea or bean soup-powder. The biscuits are in a cloth bag, the soup powder is in parchment paper and the meat in a tin. This weighs somewhat more than twenty-one ounces without the packages. Two days' rations, weighing forty-two ounces, are carried on the person, being packed in a water-proof ticking bag. Two days' extra supply is also carried in wagons. The above is a very convenient and

relatively nutritious ration; but its weight is greater than our own emergency ration, which it somewhat resembles except in the matter of fats.

The Italian "iron" or emergency ration consists merely of fourteen ounces of hard bread and eight ounces of tinned meat. Two of these rations are carried on the person. The hard bread is issued in large squares, weighing about seven ounces each. The regulations governing the use of this ration, like those of certain other foreign armies, provide that troops shall subsist upon it at certain periods during the year, so as to prevent the rations kept on hand for an emergency from becoming stale and uneatable.

In the Russian army a variety of prepared meat-cakes, according to Notter and Firth, are issued for emergency use. They consist mainly of finely powdered meat mixed with barley or peas, or oatmeal, or cabbage, or potatoes and mushrooms. Their use in the Russian service is highly extolled, although they are admitted to be difficult of digestion. The daily allowance is about twenty-five ounces. The soldiers of the Japanese army, in the late war with China, carried an emergency ration of rice in a cylindrical tin case strapped to the knapsack. The emergency ration of the Portuguese army is said by Viry to be composed of sausage, codfish, bacon, rice, biscuit, salt and coffee. The Spanish army, so far as known, has no reserve or emergency ration.

Special Preserved or Concentrated Foods.—A large number of specially prepared breads are now on the market, most of which are in the nature of bread from which the water has been largely removed by heat or pressure. The desiccated bread of Balland is made by exposure to heat for a varying period. On wetting, it is said to take up about seven times its weight of water, while hard bread takes up only an equal weight. This bread is made of flour containing a high proportion of gluten. The compressed bread of Bernard has the shape of an ordinary cracker and a slightly brown exterior. The water is almost entirely driven off by heat during the process of manufacture, which is secret. It absorbs water readily. The cracker-bread (pain biscuite) of Faillé is a similar preparation, which when wet much resembles ordinary bread. The process of manufacture is also secret. Laignel's bread is ordinary bread from which the water is removed by hydraulic pressure. Much water flows out, but when removed from the apparatus the bread still feels moist. In a day or two, however, it becomes as hard as stone—and after a year's time will still be found good and palatable. Placed in water, it slowly swells. The pain de guerre of the French army has already been mentioned. In general, the various prepared breads may, in case of necessity, be eaten from the hand. Ordinarily, however, they should be softened in water, as they are otherwise masticated with difficulty. Many of them are excellent articles for field use. Allusion may here be made to the so-called "pinole," a preparation made by mixing three parts of parched ground Indian corn and one part of sugar. This preparation has been used in our service, particularly in the southwest, and has been found to have many good qualities.

Among the preserved meats, pemmican—mentioned elsewhere—takes a high place through its nutritive qualities. It is digestible and wholesome, but is only fairly palatable. The unattractive appearance and insapidity of dried meat afford objections to its use. As prepared in this country,

dried beef is usually cured with salt. It is thus far too salty for continued use, and is also said to contain a high proportion of moisture. Canned meat is useful for the field, but is too heavy for emergency rations. A board of officers, however, some time since, reported favorably on canned roast or boiled beef as a substitute for bacon in the emergency ration, and small cans of preserved meat are used for emergency purposes in several foreign armies. The preservation of meats by various methods is discussed elsewhere. It may, however, be stated that it is extremely difficult to find a preserved meat, of small bulk, which has a pleasant taste and contains a proper proportion of nutrient elements.

Many attempts have been made to utilize meat powders in the military rations of various nations, and they were used as long ago as the Crimean War in the French army. Meat powders keep well and are highly nutritious, digestible and wholesome. Such powders are stated by Notter and Firth to possess generally about four times the nutritive value of fresh meat with bone. They possess, however, a disagreeable taste and odor. These faults have been corrected to a certain extent in the meat powder prepared by Rousseau, which was reported to the French Government to be "unchangeable, odorless and tasteless, without diminution of nutritive principles. It is capable of being preserved for many years in a simple waterproof envelope. One part of this powder is equal to several parts of fresh meat." Among the various compound preparations made of meat powders, the proportions generally adopted are: Meat powder, 25 per cent.; powdered vegetables, 50 per cent.; fat, 10 per cent.; salt, 8 per cent.; condiments, 2 per cent.

A dried food which was favorably considered in the French service, about ten years ago, was compounded of the following ingredients:

Powdered Articles.	Grams.
Meat	20.00
Peas, lentils, rice and beans	80.00
Pot herbs	5.00
Beef fat	18.00
Hog's lard	7.00
Salt	9.00
Pepper	.04
Total	139.04

The food value of the above amount was said to be as follows:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.
33.72	26.20	44.08	572

In addition to their use in soups, meat powders are also made up into cakes with various flours and powdered desiccated vegetables. Hoffman's meat powder is a superior article, and has been shown to contain seventy-three per cent. of albumen, seven of salts, ten of water and one of hydrochloric acid. Hoffman's meat cakes are agreeable, portable and easily prepared; but if used for any considerable period the appetite fails and the digestion is impaired. They have been tried in our own army in connection with hard bread, but were not received with sufficient favor to warrant

their regular issue. Johnson's and Erdmann's meat powders are similar to other preparations of this kind. The majority of meat biscuits now in the market are, as a rule, nothing more than meat powders mixed with flour and water; owing to the extreme heat to which they are exposed in baking, the meat in them is usually rendered valueless. Some combinations, however, appear excellent. Port, in 1886, brought a meat biscuit to the attention of the French authorities which was found to have many good points. Later, Scheurer-Kestner prepared a biscuit made extremely digestible by the addition of pepsin. In Germany, a biscuit is made by Schill which contains defibrinated blood instead of water. This food is highly assimilable. Another food is "Courousa," made by Jacques, which has been tried in the Russian army. The meat cakes used in the emergency ration of the last named service have been mentioned elsewhere. A preparation made by Grouvel was tried in the French army several years ago, eleven ounces being said to afford sufficient nutriment for a day's allowance. Its composition was roughly 20 parts of beef powder, 48 parts of pea flour, 20 parts of fat and 12 parts of condiment. A recent preparation tested in the German army consists of the "Kraft-zwieback," composed of wheat flour, fat and powdered meat, with a proportion of salt varying to taste. This is said to have given very satisfactory results in practice. "After the exclusive use of this food during fourteen days, devoted to field manœuvres, without any untoward results, the men of an infantry regiment were able, on the fifteenth day, to acccomplish a march of 52 kilometers." The price of meat powders is somewhat high, and during the past few years their popularity has waned through recognition of the facility with which meat of bad character could be used in their composition.

The concentrated soups and meat extracts date from the introduction of Liebig's well-known preparation. Numerous articles of this kind are now in the market—notably those of Armour, Wyeth, Brand, Kemmerich and others—which exist chiefly in the form of fluid meats, essences and extracts. Meat extract, formerly held a high place in popular estimation, particularly in Germany, but it has been conclusively demonstrated that their nutritive value is practically nil. Indeed, these extracts are not free from danger when used for any length of time, and it has been shown that animals die more quickly when placed on an exclusive diet of Liebig's extract than do those given no food whatever. These preparations, however, are not quite devoid of alimentary value; but they act as stimulants, food regulators and digestive agents rather than as nitrogenous food-stuffs. It would be a fatal mistake to use these extracts, deluded by their portability, with the idea that they contain considerable reparative materials in small compass; they are essentially alimentary aids and not true foods. If used solely in that sense, they can be turned to very good account as stimulants after very great exertion or exposure. When canned roast or boiled beef is used, the addition of beef extract to the stew will greatly increase its palatability, since it contains the substances on which the flavor of meat depends. Beef extract is now put up in the form of capsules. This is a convenient method of carriage, but when a liquid extract is used the moisture dissolves the gelatin and the capsule ultimately collapses.

Quite recently beef extracts have been prepared, both in solid and liquid form, which contain a considerable proportion of albuminous material, and

hence are true nutrients. Among these may be mentioned Wyeth's beef juice and Bischoff's "Toril"—a solid extract. The latter would probably prove of value in connection with emergency foods.

Among new concentrated food products, which may possess a value in connection with the emergency ration, may be mentioned tropon, aleuron, nutrose, somatose, eucasein and caseön. These are all patented articles, a fact which seriously impairs their availability for military use. Among these, tropon appears to be of the most value. It is a light brown, almost tasteless powder of sandy consistency, made of raw vegetable and animal materials. It is not perishable, is not hygroscopic and is not soluble in water, but is readily soluble and digested in the gastric juice. It is said to contain 90.44 per cent. of albumen—and weight for weight to contain five times as much digestible albumen as fresh beef. The analysis of this substance, as given in a subsequent table, shows its high nutritive value. Tropon has recently been given a practical trial in the German army by a detachment of one officer and twenty-five men. Special rations, wrapped in water-proof paper, were supplied by the manufacturers of tropon. Each man received three yellow packets containing one day's rations of tropon rusks and tropon chocolate, which he carried in his cooking utensils; also a round white packet containing two days' rations of the solid materials for tropon bean and pea soup, which he carried in his bread sack. During three days the men were to march, in full marching order, 30 kilometers each day and to sleep at night in the open air. The men found the tropon food easy of digestion and it kept them in good condition. Aleuron contains but about eighty per cent. of albumen, estimated on the dry basis, but is somewhat cheaper than tropon. Caseön and eucasein are made from the casein of evaporated and skimmed milk, dried and reduced to a powder. All of these articles can be used in soups, stews or even coffee. They can also be introduced into bread or crackers without altering their flavor—as much as twenty-five per cent. of tropon being thus readily incorporated into biscuits. These substances are all of undoubted food value and might with advantage be used to increase the protein of the emergency ration. Their taste, when apparent, is not at all disagreeable, and their continued employment for several days, in connection with other articles, is said not to induce distaste for their use.

Among the prepared foods the concentrated or desiccated stews and soups are very successful; being fairly compact, palatable and possessed of considerable food value. There are numerous very palatable mixtures of cooked beef and vegetables put up in hermetically sealed tins, but these unfortunately possess the fault, as regards an emergency ration, of containing a high proportion of moisture, probably sixty to sixty-five per cent., and thus being unduly heavy for their nutritive value. They can be made somewhat drier, but only at the expense of palatability. As ordinarily put up, the can contains about one and three-fourths pounds of meat and three-fourths pound of vegetables. Foods of this character have been supplied by American firms to foreign armies for a number of years. Similar to the above is the Maconochie patent ration, now being used to some extent in the British service. This ration was very highly thought of during the last Ashanti expedition, and was reported upon as being far superior to other canned meats. In the recent Anglo-Boer War it was

much used and was regarded as very satisfactory. For its weight, however, its nutritive value is very low; and, while valuable for occasional issue in the field, it can scarcely be considered as sufficiently concentrated to meet the requirements of a true emergency food. It is usually supplied in kidney-shaped tin cans weighing one and three-fourths pounds; being five and one-half inches long, three inches wide and three inches high. It is arranged with two tin straps to fasten to the waist belt, and one side is depressed so as to fit the curvature of the body. It contains one-half pound vegetables, potatoes, carrots, turnips and onions, and three-fourths pound of beef or mutton. In small recesses in the bottom of the container are secured rations of salt and pepper and a key for opening the can. It can be eaten without preparation, or made into hash or soups. Of somewhat similar nature, though much drier and hence more concentrated, are the Bovril cartridges. The contents of these cartridges are varied in their composition. The tin is usually divided into two compartments, which can be opened at the ends. The blue cartridge contains a mixture of beef, potatoes and other vegetables. It is prepared by adding double the quantity of boiling water and cooking for ten minutes. The red cartridge contains in one compartment a mixture of meat extract, pea-flour, bacon and desiccated vegetables, which is cooked by boiling; in the other compartment the contents have a chocolate basis, and may be eaten boiled or dry. These foods are very palatable and possess many good qualities. They are compact and very concentrated, are readily prepared and their food-value is very high. Their proportionate composition is also excellent, and, all things considered, the Bovril foods are probably the best for emergency use now on the market. A board of officers investigating the emergency ration reported themselves as impressed with the good qualities of the "Tanty Ration," a preparation tried in the French and Russian armies. This consists of a soup stock thickened with flour and containing cabbage and other vegetables with slices of boiled beef. It may be eaten cold, preferably with bread; and when boiled with two or three times its bulk of water it makes a very palatable dish. The proportion of meat to vegetables is said to be about one to seven. The amount of water in this food is so great as to render its nutritive value proportionately low, and it is not at all suited for emergency use.

A drier form of material for the preparation of soup is seen in the celebrated "Erbswurst" of the Germans; this being originally a mixture of pea-meal and bacon fat put up in sausage-shaped packages. According to Parkes, the sausage as first used had the following composition: protein, sixteen per cent.; fat, thirty-five per cent.; carbohydrates, twenty-seven per cent. As a food the "Erbswurst" appears to have been over-rated. Parkes states that when used too constantly it was much disliked by the men, and also had a tendency to produce flatulence and diarrhœa. When mixed with water it made a palatable soup. As a result of the success which attached to this food, many modifications were subsequently made, and are now on the market. These consist, in the main, of powdered peas with bacon or beef fat and condiments, the whole being enclosed in a water-proof cover and issued as a sausage or packet. Some few also contain powdered beef. The sausage of Boissonet, tried in the French army, contained pea-meal, lean beef and pork mixed with lard. In general, these

different kinds of "Erbswurst" are soon found to be distasteful, causing digestive derangements and at the same time lacking the sustaining qualities of fresh meat. Similar to these pea-meal sausages are certain improved combinations, packed in tin containers, of which the so-called "Standard Emergency Ration," made in this country, is a good example. The latter has within the past year been used to some extent by our troops in the Philippines. It is put up in oblong tins, which are opened with a key. This ration is said to contain pea-meal, cracker dust, powdered beef, bacon fat and seasoning. It makes a very palatable soup, or can be made into a porridge and fried when cold. In an emergency it can be eaten without cooking. It has a high food-value, as will be seen on reference to a subsequent table. Its keeping qualities, as at present supplied, are not entirely satisfactory, and no small proportion of the tins are said to ultimately become rancid in a hot climate. In general, all the above preparations, while they yield the alimentary elements of a complete food, present these in such proportions as properly only to serve as food for a very limited time. Further, in most of them the protein is vegetable, being derived from peas and beans. It is true that the chemical values of animal and vegetable protein are the same, yet experience shows the former to be very much more easily and completely assimilable than the latter.

Improving on the soup powders carried in bulk, several firms have lately put compressed tablets on the market, which are very portable, keep well, and make a nourishing and palatable soup when heated in water. The soup tablets made by the California Desiccated Food Company are composed of lean beef, beef extract and some vegetable material, usually pea or bean flour. They are seasoned and very palatable. The tablets are small, weighing less than three ounces. Those made for commercial purposes are reported to have the following percentage chemical composition: Fats, 12.22; protein, 24.79; carbohydrates, 29.55; mineral salts, 3.21. This company also makes a soup tablet containing more beef, and said to have the following composition: Protein, 47.33; fat, 11.11; carbohydrates, 20.7; salts, 11.11. The Knorr and Weidner soup tablets are successfully made in beans, peas and lentils, seasoned with herbs, pepper and salt; when desired, beef is also incorporated. The keeping qualities of these tablets are excellent. Each tablet weighs about four ounces. Knorr's pea soup is excellent, rich and palatable, tasting much like rich gravy. It ordinarily requires about ten minutes' boiling. The Weidner bean soup tablet is palatable, appetizing and nourishing, and evidently contains considerable beef extract. It requires too long—twenty-five minutes—for cooking. The Kopf pea soup requires boiling for twenty minutes. It appears to be inferior to similar articles now on the market. Edward's desiccated soups and Lazenby's soups, though excellent for officers' use, are not suitable for general military purposes, being either difficult to prepare or lacking in nutriment. When powdered beef is mixed with beef extract and powdered cooked peas, beans or potatoes, the resulting soup is almost identical with that obtained from the soup tablets now on the market. A beef combination consisting of powdered beef 150 parts, extract of beef 50, and peptone 50, is said to give excellent results. The most palatable soups are those in which the proportion of preserved vegetables is considerable.

Soup tablets are used in several foreign armies and appear to give full satisfaction. In the French army each tablet represents the daily allowance for a soldier, and it is said that a single wagon can readily carry one hundred and eighty thousand of these tablets.

PERCENTAGE COMPOSITION OF SOME CONCENTRATED AND PRESERVED FOODS AND RATIONS.

Articles.	Water, per cent.	Protein, per cent.	Fats, per cent.	Carbohydrates, per cent.	Fuel value of 100 gm. Calories.
Erbswurst (German)	7.03	21.00	22.20	45.76	480.0
Erbswurst (Knorr's)	10.86	17.50	23.96	35.74	441.1
Erbswurst (Moir's)	8.51	15.75	23.38	47.91	478.4
Pea sausage (Moir's)	11.40	21.00	32.30	27.40	498.8
Pea cake (Neumann's)	9.51	20.53	3.66	53.10	335.9
Bean cake (Schorke's)	7.98	16.72	17.20	42.10	391.1
Meat cake (Hoffman's)	6.45	24.24	24.76	39.73	492.4
Meat biscuit (König's)	5.10	8.30	6.10	76.70	405.2
Meat biscuit (Schill's)	14.50	24.70	2.50	56.70	357.0
Meat biscuit (Dunmore's)	11.89	10.81	8.06	67.94	397.8
Meat biscuit (Armebis')	8.51	15.75	15.80	58.04	449.4
Emergency ration (Woolwich)	6.94	8.00	18.11	65.58	470.0
Army ration (Grouvel's)	14.71	30.57	18.77	31.45	428.8
Soldier's ration (Moir's)	53.91	23.44	14.72	6.12	258.0
Field ration (Morel's)	27.45	32.94	23.60	10.54	397.7
Pemmican (Australian)	2.39	51.70	42.08	....	603.3
Pemmican (Arctic Food Co.)	7.25	17.75	39.55	28.32	574.5
Army ration (Maconochie)	63.56	15.30	12.76	7.25	303.9
Service ration (Maconochie)	76.59	9.72	5.48	5.88	114.9
Courousa	21.03	24.10	21.22	27.35	408.2
Pinole	7.83	7.50	4.50	72.67	370.5
Pain de Guerre	10.62	10.75	.50	76.80	379.0
Pea soup (Lazenby's)	14.16	22.75	1.60	53.58	327.8
Meat peptone (Koch)	40.60	49.69	2.87	....	230.4
Meat peptone (Kemmerich)	38.29	50.26	....	2.54	216.4
Compressed beef	61.28	31.05	5.83	....	181.5
Nao complete meat food (Military Equipment Stores, London)	52.93	13.02	20.62	10.58	303.9
Tropon (Tropon Works)	9.17	88.50	.29	1.22	510.8
Emergency ration (Tanty's)	66.01	12.66	10.22	8.83	200.6
Beef stew (Franco-American Food Co.)	66.18	15.48	11.88	5.45	215.7
Standard Emergency Ration (American Compressed Food Co.)	5.65	31.00	21.65	38.35	525.9
Standard Emergency Ration (American Compressed Food Co.).					
(A) Tablet	6.31	18.75	20.29	50.74	519.4
(B) Chocolate cake	1.00	6.62	21.36	69.44	517.8
Ration cartridge, pea, beef, etc. (Bovril Company)	14.18	21.94	17.44	40.66	444.4
Blue ration (Bovril Company).					
(A) Meat albuminoids	45.00	22.19	5.35	22.40	255.7
(B) Chocolate basis	1.30	7.25	29.60	60.06	559.0
Red ration (Bovril Company).					
(A) Meat albuminoids	27.71	21.50	15.13	30.99	406.4
(B) Chocolate basis	1.60	6.44	29.85	60.53	550.5
Ration cartridges, potatoes, beef, etc. (Bovril Company)	41.66	22.00	4.47	27.00	272.8
Emergency ration (Bovril Company).					
(A) Meat extractive basis	12.20	46.75	24.63	9.89	514.3
(B) Chocolate basis	1.66	7.25	28.97	60.19	550.5
Emergency ration, British Army.					
(A) Pemmican	3.71	59.38	26.93	5.54	641.3
(B) Cocoa paste	4.49	6.50	12.08	74.68	462.7

Desiccated vegetables were at one time a part of the army ration. They are still used in the navy, and are said to be fairly satisfactory in that service as substitutes for fresh vegetables. The military force sent against the Mormons in Utah is said to have owed its preservation from scurvy chiefly to these desiccated vegetables, when little else of an antiscorbutic nature could be obtained. During the Civil War they were not greatly liked by our troops, probably because of improper preparation. They are at present used in various foreign armies; in the British army they are said not to be generally popular. In the Ashanti expedition of 1895 the desiccated potatoes and onions were reported as being excellent, however, and the men did not seem to tire of them. In this country desiccated vegetables are made by a large number of firms. Dried potatoes are sold in two forms—sliced and granulated. In either case the potato is easily cooked and is very palatable. It should be soaked in cold water first for some time, then slowly boiled, or, what is much better, steamed. When used in soups, too great quantities should not be employed. Dried and compressed vegetables other than potatoes are also now prepared so perfectly that, if properly cooked, they furnish food of excellent character. Analysis shows that dried, compressed cabbage contains the solids of seven times its weight of fresh cabbage; while ordinary mixed vegetables, after desiccation, contain five and one-half times the solids of the fresh vegetables. Beans, cooked and desiccated, are said to be excellent. As antiscorbutics, dried vegetables are much inferior to the fresh article. Morache states that this is due to the fact that compression removes nearly all the salts and leaves little but cellulose. Still, where fresh vegetables cannot be had, the preserved articles are very much better than nothing. Dried vegetables, however, contain little nutriment for their bulk, and hence should not be included in an emergency ration, however valuable they may be for continued use in the field—and the same also applies to desiccated fruits.

For emergency use, coffee has been prepared in a variety of ways. During the Civil War it was made into extracts, mixed with sugar and sometimes milk. A little of this could be added to either hot or cold water, and did not require boiling or settling. These extracts are said not to have much of the flavor of coffee, were often adulterated with licorice or other substances and were not popular among the men, so their use was abandoned. Efforts have been made to preserve coffee, previously roasted and ground, in small hermetically sealed tins. This, however, is by no means a perfect means of preservation, since after a few months at the longest the coffee sours. The sterilization of the contents and the total exclusion of air from the can being impossible without ruining the coffee, the sealing of the package only temporarily delays deterioration. Coffee is also roasted, ground and compressed into tablet form. These tablets do not keep well and the volatile oils are soon lost; hence they must be used within two or three weeks at the latest. In the French and German armies, coffee mixed with sugar is issued in hermetically sealed tablets. Each tablet weighs an ounce and will make about a pint of coffee. In this preparation much of the aroma is said to be retained—but Laveran remarks that these tablets "are quite inferior to the freshly roasted article, though very convenient for transportation." Experiments have

been instituted with reference to sugar-coating the coffee tablets, but no good results appear to have been obtained. In our own service no better plan has been found for the emergency ration than by supplying the freshly roasted and ground berry in small packets, trusting to opportunity to use or replace the coffee before great deterioration has occurred. Tea is preferred by some for field use, especially in cold climates. In bulk it is somewhat difficult to transport, but this objection is removed by compression, the bulk being reduced to about one-third in the process. Compressed tea is said to be more economical than the ordinary article through the breaking up of the vegetable cells through pressure. Woodruff states that in using compressed tea the whole strength is given up to boiling water in five minutes, while a similar result cannot be accomplished with ordinary tea in less than five hours. A tablet weighing one-third of an ounce suffices to make three or four pints of a strong infusion. This article is excellent for emergency rations. Saccharin is used largely in tea and coffee tablets to give the desired sweetness of taste. For this purpose alone it is satisfactory; but it furnishes no energy whatever and, as already stated, is much inferior to sugar as a component of the emergency ration. Cocoa is used in the English emergency or reserve ration. It is put up for field use with honey or sugar and milk, made up in the form of a paste, and its keeping qualities are excellent. It may be eaten as food or prepared for use as a beverage. It is palatable and nutritious and its use in our service is much to be recommended. Kola nut, in various forms, has been proposed as part of the emergency ration through its supposed properties of relieving fatigue and masking the sense of hunger. It has been much exploited in this country, but reliable investigation has shown that the slight stimulant properties possessed by the fresh nut are analogous to those of caffeine, and that this article has no practical value for the military service. Wine, rum and brandy are served out to the soldiers of nearly all foreign armies under the conditions in which the emergency ration is consumed. Their use in this manner would probably never be tolerated in the army of the United States, even under circumstances when it might be of advantage.

The Travel Ration.—When troops travel otherwise than by marching, or when for short periods they are separated from cooking facilities and do not carry cooked rations, the following articles are issued in lieu of all components of the ordinary ration.

Articles.	Per 100 rations.	
Soft bread	pounds,	112½
Or hard bread	"	100
Beef, canned	"	75
Baked beans, one-pound cans	number,	33
Or baked beans, three-pound cans	"	15
Coffee, roasted	pounds,	8
Sugar	"	15

After troops have been subsisted upon the travel ration for four consecutive days, they may be allowed canned tomatoes in addition to the above ration at the rate of one pound of tomatoes per man per day. Unconsumed articles of the travel ration are not sold as savings, but are turned over to the commissary. When supplied with cooked or travel rations,

soldiers may be allowed twenty-one cents daily per man for the purchase of liquid coffee, in lieu of the coffee and sugar portion of the ration.

The chemical composition and fuel value of this ration, per man, as ordinarily drawn, are as follows:

Articles.	Protein, grams.	Fat, grams.	Carbohydrates, grams.	Fuel value per ration, Calories.
Soft bread	48.45	6.12	269.28	1,355
Beef, canned, corned	89.47	64.61	....	960
Beans, baked (one-third pound)	10.42	3.77	29.60	200
Sugar	....	....	54.70	220
Total	148.34	74.50	353.58	2,735

The above diet is obviously illy balanced and contains an undue amount of nitrogenous material for the carbohydrates present. The fuel value of the ration, however, is probably not far from the actual requirements of the soldier under the conditions in which the ration is intended for issue. The ration itself is not particularly palatable at best, and after a journey of three or four days it may actually become distasteful. This is a defect especially due to the lack of a suitable accessary food to eat with the bread. It would, therefore, be much to the advantage of the soldier if the addition of a small amount of fruit jelly or canned fruit was authorized. This need not be greater than a daily allowance of four ounces of jelly or half a pound of canned fruit per man. Such an improvement would add little to the cost, since the articles named are cheap and the allowance of canned tomatoes, presumably added as an antiscorbutic for long journeys, would thus be no longer required. An addition of jelly or canned fruit would also largely correct the deficiency of the ration, above noted, as regards carbohydrates.

While ordinarily the travel ration is consumed for such short periods and under such conditions with respect to the expenditure or energy as to render its exact conformation to dietary standards a matter of no great importance, yet its use may be unavoidably prolonged by unforeseen circumstances—as was the case during the war with Spain—and its evident deficiencies therefore become a serious matter well worthy of rectification.

CHAPTER VI.

MILITARY CLOTHING AND EQUIPMENT.

I.

CLOTHING.

ACCORDING to Poore, the main objects to be sought in clothing the body are to maintain the bodily temperature, and, by preventing the loss of animal heat, to diminish to some extent the demand for food; to allow the chief heat-regulating mechanism—*i.e.*, the evaporation from the skin—to proceed with as little hindrance as possible; to allow all muscular acts the greatest possible freedom, and to avoid interference with physiological function, or any compression of the body, in so far as may be possible; to protect the body from heat, cold, wind, rain and traumatism.

Uniformity.—Since the soldier is permitted to have no choice in the selection of the clothing which must be worn by him, it becomes the duty of the Government to anticipate and properly provide for his probable needs in so far as they can be foreseen. Military clothing should also be practically adapted to the purpose for which it is intended, a common-sense requirement far too frequently ignored. Considerable diversity and multiplication of uniforms is highly undesirable. In time of war the soldier should preferably wear no different clothing from that worn in peace; and thus the military uniform should be suitable for campaign as well as fit for garrison duty, parade or other ceremonial. After suitability has been obtained, the uniform may be allowed a certain amount of ornamentation and smartness, since these qualities play a considerable part in attracting recruits and the satisfaction of a not undesirable element of vanity in the soldier. In the British army the privilege of wearing a showy uniform is recognized as being one of the most powerful factors in inducing enlistments. The cavalry regiments in that service are never short of recruits even when the reverse is the case among the foot troops; and this is generally believed to be due to the more elaborate uniform worn by the mounted soldiers, since service in the cavalry, by itself, is much more arduous than in the infantry. Any ornamentation authorized, however, should be readily detachable, so that for purposes of campaign the uniform proper may be rendered inconspicuous and severely simple; and in the field no ornamentation should be permitted save such very slight modifications as may be necessary for the designation of rank. Uniforms should never vary from the standard pattern, so as to allow of a more ready and certain supply from clothing depots. The system of regimental uniforms was responsible for much hardship and suffering among the British troops in the Crimean War—in spite of which the modification of clothing for the designation of various regiments and groups of regiments is still customary in certain European armies, while in nearly all foreign cavalry services the use of the regimental uniform is even yet more the rule than the exception. State militia

should possess the regular army uniform, devoid of special cut or regimental facings, so that if called into the general service any deficiencies may be readily remedied from a common stock. While for convenience of administration clothing should be uniform for each arm of the service, this need not necessarily be so for the entire army.

Cut.—Military clothing should be simple in cut and readily adjusted or removed. Whatever be the kind of garment, it must assure liberty of movement to the soldier in all his members; since if freedom of action is impeded by tight clothing an unnecessary expenditure of energy is required and the efficiency of the soldier by so much impaired. The uniform should be of comfortable looseness, particularly about the hips, arms, neck and chest—compression of the latter being especially dangerous to the younger class of recruits in whom development is incomplete and the chest is enlarging under the influence of training and exercise. A tight collar presses on the neck and induces cerebral engorgement with resulting headache, vertigo, frequent interference with vision and greatly increased liability to sunstroke. In this connection it is of interest to note that until the last generation the regulations of the larger European armies as well as our own required the wearing by officers and men of a stiff leather or pasteboard stock, two or three inches in height and scooped out at the chin, for the purpose of imparting an artificial erectness and rigidity. For the convenience of the soldier, and the better carriage of small articles on the march, the uniform should be amply supplied with stout pockets.

Grade.—For the maintenance of health as well as comfort, military clothing should vary in warmth with the climate or season in which it is to be used. Insufficent clothing for a cold climate presents obvious disadvantages, and special protection must be provided for troops serving in cold northern posts. On the other hand, too heavy clothing in warm weather is a powerful factor in the promotion of sunstroke and exhaustion, the latter also markedly favoring the occurrence of infectious disease. Hiller found that during marches of about an hour's duration, during May, the rectal temperature in the fully equipped German infantryman rose to 39.4° C. where lightly clad soldiers had no rise beyond 38.4° C. Soldiers should also be required to modify their clothing, from time to time, as much as may be practicable according to temperature, more especially as regards falling temperature. Inattention in this respect to climatic or seasonal variation is prolific of sickness, and the matter can often be advantageously regulated by orders. In the colder stations, where furs are issued, the command should be prohibited from wearing such clothing after the actual necessity for its use has passed. When in the field, also, as much of the outside clothing as can be comfortably dispensed with should be removed at night. The leggings and shoes should always be taken off, or at least the lacing unloosened, and no constriction of any part of the body during sleep should be permitted.

Material.—In the selection of the material for the uniform of the soldier, the chief points to be considered are its permeability to air, durability and the property it has of conducting or absorbing heat. In general, it should protect not only against cold but also the rays of the sun, readily absorb perspiration and check its too rapid evaporation, and be as impervious as possible to wind and rain. For underclothing, loose tissues are preferable to compact textures, since they are more hygroscopic; while

closely woven fabrics are desirable for outer garments, since they are more durable and readily part with acquired dust.

Wool is much the best material for the military uniform, since in a variable climate, or where there are sudden changes of temperature, its use secures for the soldier a more equable body temperature. While, taken fibre for fibre, it probably does not vary so much from linen or cotton as is generally believed, it is usually woven in such a way as to entangle large quantities of air in its meshes; this, through its non-conducting properties, prevents sudden cooling or heating. Wool takes up water and perspiration readily and gives them off comparatively slowly, thus reducing cooling by evaporation to the minimum and regulating the heat dissipation of the body. Woolens are often fraudulently sophisticated in the process of manufacture, and their durability and heat-retaining value greatly lessened thereby. "Shoddy" woolens are made from old woolen rags torn asunder and respun with the addition of fresh material. Exclusive of cost, wool has few disadvantages, its main fault being shrinkage and hardening after washing. Some persons are said not to be able to tolerate wool next the skin on account of its irritating properties, but if its use be persisted in for a fortnight this intolerance will be found to disappear.

Cotton fabrics are hard, durable and cheap. If smoothly woven and of a light color, cotton makes extremely cool garments for hot weather. If warm clothing is desired, the material must be loosely woven so as to leave large interspaces for the retention of air in the texture. As usually woven, cotton fabrics are comparatively non-permeable to air, possessing little more than half the porosity of flannel. Cotton is largely unsuited for military purposes, since it cannot be safely worn next the body by those subject to sudden temperature changes, or liable to undergo severe exercise, unless the clothing be changed immediately after the exercise or some additional garment is donned to prevent too rapid evaporation and chilling. Cotton worn over light wool makes an admirable combination for warm weather or climates. Cotton duck sheds water excellently, protects against wind and is a fair non-conductor of heat, but in severe winter weather it has the disadvantage of becoming so cold as to render contact with it almost unbearable. Canvas lined with blanketing makes a very satisfactory protection for cold climates.

Linen is very hygroscopic. As ordinarily woven it is an excellent conductor of heat, and since it is readily saturated with perspiration it requires for the maintenance of health such frequent changes of garments as cannot be obtained in the military service. A new weave of linen, the Deimel linen mesh, is valuable for the amount of air held in its interspaces, and its use removes many of the objections formerly attaching to this material.

Leather, with or without the hair upon it, is impermeable to the wind and keeps the body surrounded by a layer of warm air. It finds its chief use in the military service, outside of the far northern stations, in the manufacture of the foot covering and portions of the equipment; for which, on account of its durability, pliability and practical imperviousness to water it is well suited.

Rubber, oil-skin or similar water-proof material has a special but limited value in the military service for the protection which it affords against rain.

Color.—The choice of color for the military uniform should be based on

the practical rather than the æsthetic or sentimental, although unfortunately the latter considerations are the ones on which selection is usually made.

The hunter always tries to harmonize his clothing to his probable surroundings, and the Apache, in battle, endeavors to render his person as inconspicuous as possible. Among lower forms of life there are many striking examples of the powerful influence of color, as adapted to environment, upon the successful maintenance of existence. Grouse, snakes and other creatures closely harmonize in color with the local conditions in which they are found. Arctic hares, ptarmigan and foxes change color with the season, while the chameleon varies its hue with each change of surroundings. It should never be forgotten that conditions which govern lower life in the struggle for existence apply also to man in his wars with one another. At the time when infantry opened fire at no greater distance than one hundred and fifty to two hundred yards, color was not of so much importance, although even then of advantage in concealing numbers and evolutions; but to-day, with long-range arms using smokeless powder, it is of the utmost importance to proscribe all colors which can be distinguished at long distances and so furnish a mark for hostile sharpshooters. The readiness with which a color can be seen of course largely depends upon its background, it becoming less and less visible as the two shades approach each other. Thus a black object, indistinct on a dark background, becomes very apparent by contrast if surrounded with snow.

The results obtained by Gerard and Devismes, with reference to the visibility of targets of different colors placed at the distance of 300 and 600 meters and observed under very diverse conditions of light and background, are shown in the following tables:

Color of Target.	300 Meters Distance.						Clear Weather.				Cloudy Weather.						At Night.	
	Open country.	Rocky country.	On the seashore.	Over water.	Against earthworks.	Against stonework.	Daybreak.	Morning.	Noon.	Sunset.	Dawn.	Morning.	Noon.	Sunset.	Rain.	Rain and fog.	Moonlight.	Starlight.
Scarlet	4	4	3	2	5	4	4	3	3	4	4	3	4	6	3	3	4	5
Green	3	5	4	4		3	3	4	4	3	5	7	3	8	4	4	3	4
Dark blue	2	4	3	7	3	2	2	5	3	2	6	6	3	8	4	4	3	4
White	4	1	2	1	1	2	1	1	2	1	8	8	1	8	2	2	8	8
Gray	7	7	7		6	7	7	6	7	5	8	8	5	8	6	6	8	8
Ashy-brown	7	7	6		7	6	6	7	6	6	8	8	6	8	6	7	8	8

Color of Target.	600 Meters Distance.					
	Open country.	Rocky country.	On the seashore.	Over water.	Against earthworks.	Against stonework.
Scarlet	4	5	3	5	5	4
Green	3	4	5	4	4	3
Dark blue	2	3	4	5	3	2
White	1	1	1	1	1	2
Gray	6	8	7	8	8	7
Ashy-brown	7	8	6	8	8	6

[The number 1 designates the color seen the most readily and the number 7 that seen least readily. The number 8 signifies that the target of that color could not be seen at all.]

According to the above figures, the arrangement of colors in the order of their conspicuousness, averaged under the various conditions in which the experiments were carried out, is as follows:

White (most conspicuous)	2.82	Green	4.08
Dark blue	3.75	Gray	6.87
Scarlet	3.91	Ashy-brown (least conspicuous)	6.91

From this it is seen that under all conditions the United States army blue draws fire about twice as readily as the recently adopted light brown khaki uniform, the latter possessing the most desirable of all colors. The fact has also long been noted, in our practice manœuvers, that when one command was clothed in the brown fatigue dress, such troops disappeared from view long before those wearing the regulation blue uniform. Clearly, the blue uniform should not be worn in campaign, even if its retention be thought necessary for garrison use. Besides being least conspicuous, the effects of ordinary wear are also less apparent on fabrics of a light brown or neutral color.

Common experience, as well as the investigations just noted, shows that neither white, blue nor scarlet is a suitable color for military clothing. The Austrian army abandoned the white tunic after its disastrous war with Italy; and the English reserve their scarlet tunics for parade and ceremonies, adopting the brown khaki for actual service. The Russian army uniform is dark green, most excellent for summer service in a wooded country, but this color is properly modified for wintry weather and a gray landscape by the use of a gray sheepskin cap and long overcoat of a slaty-gray color. The French infantry wear dark blue coats, red trousers, forage caps and blue overcoats—the most deadly combination used by any army except that found in our own garrison uniform. The Belgian uniform is similar to our own but slightly less objectionable, the tunic being a lighter blue and the trousers gray. The color of the Spanish uniform on the home stations is similar to the French, but the coloring is also somewhat subdued. The advantage of the light green coat of the Italian service is more than neutralized by the white shakos, trousers and leggings which are also worn. The German uniform of slate-colored tunic and trousers of lighter shade is deadened in winter by a neutral tinted great-coat—the color of the Japanese uniform for cool weather being practically identical with that of the German service.

No part of the clothing or equipment should be of burnished metal, since through the glint of reflected light a hostile fire may be drawn from long distances. Buttons should therefore be of horn or bronze metal. The Russians have discarded metal scabbards in favor of those made of wood and covered with hard rubber. No colored facings, except perhaps a narrow shoulder strap to designate the arm of the service, should be allowed on the uniform, nor should any conspicuous mark of rank be permitted—as tending to draw fire. Cross straps of contrasting color should never be employed, nor should our blue cartridge belt be used with khaki uniforms. White helmets make a conspicuous mark, and their use was soon abandoned by the French in Tonquin, in favor of a neutral gray, for this reason.

Permeability.—Its perviousness to air plays an important part in the

hygiene of clothing. If there be not ready atmospheric circulation and resulting evaporation of sweat from the surface of the skin, a disturbance in the mechanism regulating the dissipation of heat is certain to result; this varying in its results from slight discomfort on the part of the wearer to the production of exhaustion, heatstroke and even death. Pettenkofer found that the permeability of various textures to air, flannel being considered as 100, was as follows:

Flannel	100	Silk	40
Linen	58	Glazed leather	1
Buckskin	51		

Hiller compared the perviousness of wet and dry cloth, using a pressure of 28 cm. of water, and demonstrated the truth of the common idea that moisture renders fabrics much less permeable to air. His results on the uniform clothing of the German army, measuring the amount of air which would pass through a given surface in a given time, were as follows:

	Dry clothing. (Liters of air.)	Wet clothing. (Liters of air.)	Diminution in Permeability.
Military cloak (cavalry)	54.77	14.9	39.87
Officers' doeskin	48.41	2.9	45.51
Military tunic (soldiers')	58.62	5.3	53.32
Military trousers (soldiers')	52.18	9.2	42.98

After soaking in water for twenty-four hours the cloth of the German tunic would not permit the passage of air under a pressure of less than 3 mm. of mercury. Kolb estimated from his experiments that, if the permeability to air of the uniform of the French officer and soldier when dry was regarded as 100, the exposure of such uniform to an atmosphere saturated with watery vapor reduced its permeability to 75 in the case of the officer, and 50 in the case of the soldier. Thus on close, humid days, or after a shower, the damp or wet clothing of marching soldiers does much to favor the occurrence of overheating and sunstroke among them.

Absorption and Conduction of Heat.—The absorption of heat from the solar rays depends only to a slight degree upon material or texture and is chiefly influenced by color, absorption of heat being least in the light shades and increasing according to the following scale—white, light yellow, dark yellow, light green, dark red, dark green, light blue and black. Laveran found that a thermometer wrapped with white wadding and exposed to a summer sun gave a temperature of 32° C. where another thermometer wrapped in black wadding registered at the same time 42° C.; and Coulier found that a thin white cotton tissue superimposed on dark woolen reduced the temperature of the latter by as much as 12.6° F. Since white has the least absorbent power as regards heat, it is the usual color for clothing in tropical regions. It is, however, not suited for military purposes except in garrison, since it is readily soiled and affords a most conspicuous mark for the enemy. For military use in summer or tropical campaign the color of the uniform should be of light gray, light yellow or dusty-brown; the latter, as exemplified in our khaki clothing, probably best answering both sanitary and military requirements under all circumstances. From its greater absorption of the solar rays it is very desirable that the blue flannel shirt, in preventing overheating of the soldier,

be discarded for tropical service—where a blouse is rarely worn in the field—and be replaced by a shirt of similar material of light brown color.

When not in the direct solar rays the absorption of heat depends upon the material and texture, color entirely ceasing to be a factor.

Kolb found that wet fabrics conduct heat more readily than dry fabrics; old clothing better than new clothing. On the other hand, clothing, when wet, radiates heat less readily than when dry. Color appears to make no difference in the power of heat radiation—the power of absorbing heat, other than that of the direct solar rays, being in general equal to the radiating power. Hammond noted that a cylindrical vessel containing water at 150° F. cooled 10° F. in fourteen minutes if covered with woolen United States army uniform cloth, and in seven and one-half minutes if covered with linen shirting, the other conditions being the same.

The absorption of odors partly depends upon color. According to Parkes, black absorbs the most; the absorptive power varying in a decreasing scale through blue, red, green, yellow and white. As far as texture or material is concerned, the absorption of odors is directly proportionate to the hygroscopic properties possessed by the fabric. Wool absorbs odors more readily than cotton or linen—and hence the suitability for its purpose of the cavalry stable frock, made of white cotton duck.

Absorption of Moisture.—Coulier distinguishes between water of interposition—retained in the meshes of the fabric by capillarity—and hygroscopic moisture due to the absorption of water by the fibers of the material itself.

According to Klas-Linroth, the amount of hygroscopic moisture taken up by a given fabric is determined by the amount of atmospheric humidity, temperature having little influence. The rapidity of absorption is very great during the first few minutes, and sixty per cent. of the water necessary to saturation is then taken up—the maximum being reached in twenty-four hours. Hiller showed that flannel was more than twice as hygroscopic as cotton. Pettenkofer found that 1,000 parts of dry flannel would take up 913 parts of water, while the same weight of linen would take up but 740. On slowly evaporating this water for seventy-five minutes the linen lost 511 parts of water, the flannel 456. During the thirty minutes following, the linen was deprived of 130 and the flannel of 148 parts; during the next thirty minutes the linen 44 and the flannel 115.

It has been shown that fabrics applied to the naked skin take up moisture from it less rapidly than does the external air. Flannel placed under these conditions took up, according to Klas-Linroth, only 44 parts of water per 1,000 of the fabric, where 174 parts were taken up by the free air.

With regard to the rapidity with which water is absorbed by clothing, as well as its amount, on exposing a French infantry overcoat to an artificial rain of moderate intensity the following results were obtained by Kolb:

	Kilograms.
Weight on removal from the storehouse	2.225
Weight after twenty-four hours' exposure in an atmosphere saturated with moisture	2.355
Weight after an exposure of one minute to the rain	2.605
Weight after an exposure of three minutes to the rain	3.140
Weight after an exposure of six minutes to the rain	4.385
Weight after an exposure of fifteen minutes to the rain	5.175
Weight after drying for twenty-four hours in the open air	2.970

He also found that although old cloth took up moisture at the outset much more readily than new, this relation was soon reversed; the worn fabric ultimately being able to retain less moisture than the new. Lorenz has experimented with regard to the increase in weight of the uniform of the German foot-soldier from water of interposition, obtaining the following results:

	Kilograms.
Total weight of clothing before wetting	7.074
Total weight of clothing after immersing in water	18.273
Total weight after drying for twelve hours, in a damp and cold atmosphere	11.253

Experiments made by the writer show that the blue uniform or overcoat of our service will take up five or six pounds of moisture even in a rainfall of no very great intensity. Although this weight is small and is a matter of no special importance when the distance to be marched is short, the matter becomes quite different during a long day's journey. Five pounds carried through an infantry march of sixteen miles is equal, in the expenditure of energy required, to carrying eighty pounds one mile—or, if the weight of the equipment be assumed to be about forty pounds, the weight of the moisture absorbed practically diminishes the day's march which the soldier can perform by two miles. Obviously the difference of two miles, in the attempt to seize a strategic point or re-enforce a fighting column, may mean the difference between victory and defeat; and the failure of Napoleon's re-enforcements to arrive at Waterloo was said to be due much to such conditions as are given above.

These facts show the greatly increased expenditure of energy required for the carriage of the clothing during rainy weather, in addition to the unfavorable condition of terrain as regards marching so produced, and illustrates the importance of proper water-proofing of the outer garments of the soldier as a matter of military and strategic importance as well as a sanitary precaution.

Water-Proofing.—Wet clothing is heavy and uncomfortable, and hence is both fatiguing and depressing to the morale of an army on the march. Fabrics conduct heat much more rapidly when moist and their permeability to air is greatly impaired, thus both favoring chilling of the body during cold and interfering with the evaporation of perspiration in hot weather. Water-proof clothing of proper character would, therefore, be of the greatest advantage to the soldier—but tissues which are impermeable to both air and water are totally unfit for general military purposes. Rubber garments, or those of oil skin, cannot be safely worn any length of time by marching soldiers, since, while impervious to water, they prevent the passage of air and keep the wearer constantly bathed in moisture through the non-evaporation of perspiration; the same objection applies also to the use of cloth water-proofed by the use of gutta-percha, shellac, lacquer, paraffine and similar agents. Under severe exercise the use of water-proof garments of this character soon becomes very distressing.

Scoffern advised treating cotton or linen material with a bath of ammoniacal cuprous oxide; this substance possessing the power of bringing cellulose into a solution from which it may be precipitated by the action of an acid. A better plan for the water-proofing of such clothing, how-

ever, is based upon the deposition in the fibers of an insoluble compound obtained by passing the tissue through a bath of a metallic salt, usually iron or alum, and then treating it with a solution of soap. This method was improved upon by Dujardin, who employed a solution of acetate of aluminum, which decomposed on drying and caused a deposition of the metal in the texture. Hiller and Lorenz found that acetate of aluminum used in this manner, rendered garments satisfactorily water-proof, while at the same time it permitted the access of air in sufficient quantity to cause the ready evaporation of the perspiration. In the experiments of the former an unimpregnated fabric permitted the passage in a given time of 54 liters of air, where similar material, after being water-proofed, allowed the passage of 52.98 liters—but if the untreated cloth was thoroughly wet only 14.9 liters of air passed through, while the water-proofed fabric permitted the passage of 39.8 liters under the same conditions. Hiller also found that under a pressure of 6 cm. of water an unimpregnated cavalry cloak was saturated in less than half an hour, while the passage of water did not occur in twenty-four hours with the same garment after water-proofing with acetate of aluminum. The cloak after being rendered impervious by the use of this substance, when immersed in water, absorbed 1,320 gm. (three pounds) of water less than a similar cloak not rendered water-proof. Lorenz found that the acids contained in sweat dissolved the aluminum, as did also alcohol, benzine and vinegar, and that vigorous or repeated washings also impaired the impermeability. By the use of aluminum acetate the color of tissues is altered but little if any, while the amount of the metal deposited in the fabric is so small as to make practically no increase in weight. By this procedure the tissues are not injured; coarse and rough textures giving better results than finer ones. The method is very inexpensive, and the entire outer clothing of the soldier can be water-proofed at a cost of about one dollar for each hundred men. It is stated that this method is now employed in the British army for the water-proofing of khaki clothing, for which purpose it is very satisfactory.

Early in 1899, the attention of the writer was casually attracted to the well-known property of repelling moisture possessed by blankets woven by the Navajo Indians from yarn spun by themselves from native wool—and further investigation showed that this water-proof quality was dependent upon the presence of wool-fat, a substance which among civilized peoples is carefully removed from fleece before it is dyed and spun. Experiments were then begun and carried on for a number of months, when it was learned that this method of water-proofing had also been discovered by Berthier and Kolb in France at about the same period. The writer, after some experimentation, decided upon the use of a solution made up of 20 to 30 gm. of lanolin, previously dehydrated, dissolved in 1 liter of benzine. Kolb employed neutral wool-fat or suint, dissolved in petroleum ether in the proportion of 10 gm. of suint to 1 liter of solvent. Recently a process has been adopted commercially by which the cloth is impregnated with wool-fat by the use of heated steam rollers. The first plan appears to give fully as satisfactory results and has the advantage of being cheaper. Woolen fabrics, as might be expected, give much more satisfactory results than those of vegetable origin—though the water-repellent qualities of the latter are much improved by this process.

The process of water-proofing is very simple and can be readily carried out by any one, even in the field. The clothing to be water-proofed is merely immersed in the solution, the garment wrung out and the excess of solvent allowed to evaporate rapidly in the open air; about 3 liters of the solution being required for the entire effects of each soldier. Clothing impregnated with wool-fat or lanolin may be worn both in rain or sun without ill effects, permits the ready evaporation of perspiration and affords better protection against rain than do fabrics water-proofed with acetate of aluminum or other chemical bodies. The garments impregnated with wool-fat are even more permeable to watery vapor than clothing not so treated; this being explained by the fact that moisture cannot penetrate the fibers of the cloth and cause their swelling, with consequent diminution of gaseous permeability. Little water is absorbed by material treated in this manner, Berthier finding that a piece of untreated cloth, weighing 25 gm. when dry, had its weight increased to 69.5 gm. by being exposed to a heavy rain; while a similar piece of cloth, after impregnation with lanolin, weighed only 30.5 gm. after the same exposure. In the writer's experiments it was found that a woolen blanket, treated with a three per cent. solution of lanolin, did not permit the passage of water under a pressure of less than one inch, or about two-thirds of an ounce pressure to the square inch. It is noticeable that by the use of this method of water-proofing the comparative conductibility as to heat is slightly greater than in dry, untreated fabrics, but is considerably diminished when compared with similar wet fabrics. The gaseous permeability of cloth treated in this manner is only slightly impaired by wetting.

The water-proofing by wool-fat appears to be permanent as regards ordinary conditions, moderate washing having no effect upon the impermeability produced by lanolin, although prolonged washing or the use of strongly alkaline soap causes a slight diminution. The expense of water-proofing the soldier's uniform by means of this agent is inconsiderable, amounting to only about twenty cents per man. In using this process, which is founded on nature's provision for the protection of the animal, care should be taken to ensure equality of impregnation. The best plan would undoubtedly consist in passing the cloth, in bolts, through rollers, after being soaked in a strong solution. If large garments are soaked and then hung up, gravity will cause the solvent to run down and thus bring about an excess of the wool-fat in the lower portion of the fabric. In such a case the excess of solution should be wrung out, and the position of the garment be continually changed until most of the solvent has evaporated. In warm climates as strong a solution as five per cent. can be used on clothing, but in cold climates garments treated with this strength become slightly stiffened and "felty" in cold weather. Weaker solutions should therefore be used in the latter instance, no greater strength than two per cent. being employed.

The proper use of wool-fat for the water-proofing of the military uniform clearly has many practical advantages. These may be summed up as follows: Impermeability to rainfall, free passage of air and water vapor, increased capillarity, no increase in weight, no alteration in appearance, color or odor, increased solidity and strength. To this may be added cheapness, ready attainment of water-proofing materials and simplicity of operation.

SPECIAL ARTICLES OF THE UNIFORM.

The Head-Covering.—The ideal military headgear should be light in weight and color, be well ventilated, and offer little resistance to the wind. It should protect the head from heat and cold, and shield the eyes and the back of the neck from sun and rain. Its centre of gravity should be in the same vertical line with that of the head, since otherwise the soldier will be required constantly to replace it in maintaining its equilibrium. It should not constrict the head nor interfere with the use of the soldier's weapons, while it should be a protection at night in the field and be sufficiently sightly for military ceremonial. It is thus apparent that the perfect military headgear has yet to be discovered.



FIG. 96.—Types of Military Headgear. United States Army uniform cap, without insignia.

The form and color of the military head-covering are of great importance in preventing over-heating of the head, and sunstroke, by the solar rays. Jousset, in Senegal, observed that, in a temperature of 50° C. in the sun, the temperature under a soft black hat was 45° C., and under a light gray helmet 32° C.; while Geraud has noted a temperature of as much as 52° C. in the metallic helmets of the French cuirassiers. It is easy to understand how readily sunstroke may occur under such conditions. The crown of the head-covering must always be sufficiently high to afford a proper air space above the head, and, if necessary, to permit the placing therein of a damp handkerchief, grass or leaves if such action be required by prolonged exposure to a hot sun.

The forage cap of our service is very light and adapts itself well to the head without producing constriction. It has a height in the crown of three and one-fourth inches; the diameter of the top, laterally, being about six and one-half inches, and from front to rear seven and five-eighths inches. The cap is covered with dark-blue cloth and lined with black satin. The shape is maintained by a foundation of haircloth, and it is still further stiffened around the side by a band of split leather one-sixteenth of an inch thick and two and one-fourth inches wide. The slanting visor has a width at the centre of one and five-eighths inches and is lined with embossed green leather. The weight of the cap is about five and one-half ounces. Ventilation is provided through the perforated eyelets on each side. The disadvantages of the forage cap are that it is hot in summer, cold in winter and does not sufficiently protect from the rain and sun. It also deforms somewhat readily, particularly after repeated exposure to rain, and is frequently accused, on rather insufficient evidence, of producing baldness. It affords no protection to the back of the head and neck, and for this purpose a loosely floating neck-cover—the "couvre-nuque" and "havelock" of the French and English services—should be added if the cap is worn in the field in a hot season or climate. When its use is restricted to garrison service in temperate climates, however, the forage cap has no serious defects.

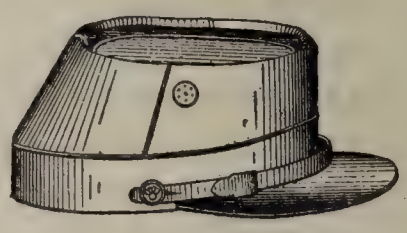


FIG. 97.—Types of Military Headgear. French kepi.

The helmet, so long the distinctive head-dress of the soldier, is no longer required as a protection against possible saber strokes, and with this the only reasonable argument for its employment in the military service at once ceases to exist. The full-dress casque used in our army can be mentioned only to be condemned, since it has many grave defects and no advantages over more hygienic headgear, even for parade. This helmet is made of felt, and weighs, with ornaments, from seven and one-half to eight and one-fourth ounces. The visor is finished inside in green morocco. The helmet is furnished with a chin strap to hold it in position, and for additional security, when issued in the mounted service, it is provided with a helmet cord. No provision is made for ventilation in this helmet, which is stiff, unyielding and illy-balanced. It affords no protection against cold, and, being both black in color and badly ventilated, is excessively hot in warm weather. The helmet of the British infantry is made of cardboard covered with water-proof cloth. It is well ventilated but is heavy and cumbersome, weighing fourteen and one-half ounces. The old German helmet, made of leather, weighed sixteen ounces and was ornamented in copper metal. More recently parts of the ornaments have been removed and others made of aluminum. This helmet is provided with orifices for ventilation at the base of the spike, and by turning the latter the ventilation can be regulated.



FIG. 98.—Types of Military Headgear. United States Infantry full-dress helmet.



FIG. 99.—Types of Military Headgear. German Helmet.

The campaign hat used in our service is made of drab felt and weighs about three and three-fourths ounces when complete. The block is five and three-fourths inches deep to center of top; the brim being two and three-fourths inches wide in front and rear and three inches wide at the sides. The hat is furnished with a sweat-band two and one-fourth inches wide, and is provided with small punched holes on the side for ventilation. For use in hot climates it is issued with an air space under the sweat band, while a ventilating hole is made on each side, guarded by light wire gauze for better ventilation. The advantages of the campaign hat are many, while its faults are comparatively few. Except for use in winter in very cold climates, it is probably the best military headgear which has yet been devised, being extremely popular with troops and worn by them in preference to any other head covering, even in the tropics. Its defects include the large surface which it exposes to the wind and the readiness with which the material breaks down on exposure to wet weather—the latter being easily remedied by contracting for hats of better quality and water-proofing them

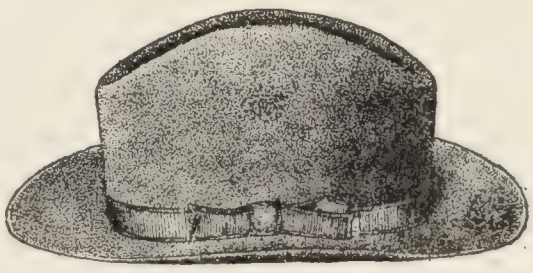


FIG. 100.—Types of Military Headgear. United States Army Campaign Hat.

before issue by the use of wool-fat. This hat cannot be comfortably worn by the sleeping soldier, owing to its broad brim; and when protection for the head at night is desirable, a small, soft cap may be advantageously carried in the equipment, as is done in the French, German and English armies. It has been recommended, to give a more dressy effect to the campaign hat, that the brim on one side be looped up and fastened by a rosette or metal ornament. This implies a sacrifice of the practical and hygienic to the æsthetic—for it is obvious that if the protection afforded by a brim is desirable for one side of the head it is equally so for the other. Except in cold weather the crown of this hat should never be creased, but should be left intact or else drawn to a point in Mexican style to ensure a proper air space above the head of the soldier. This rule should be enforced by company officers. The nearest approach to the campaign hat used in foreign services is the headgear worn by certain of the British and German colonial troops in Africa, and by colonial forces in Australia and New Zealand. The Alpine troops of Austria and Italy wear a slouch hat, adorned with cock's feathers, resembling it slightly in appearance.

Straw hats, of a pattern approved by the commanding officer of the post, are permitted to be used at the more southern home stations during summer. Advantage of this permission, however, is rarely taken.

In foreign military services the head-covering varies greatly in pattern. The French infantry kepi is similar to the forage cap discarded in our service several years ago, after a generation of usage. In the Belgian army a shako is used in the field, this being shaped like a truncated cone and having a black leather top, patent leather visor and chin strap. In the German Landwehr a similar shako is also issued. In the Spanish and Italian armies a modified shako is employed, while in the British and German services the helmet is used. The summer head-dress of the Russian infantry is a cap similar to that used by the sailors of our naval service; a visorless sheepskin cap being used in winter. For garrison duty the Austrian cap is similar to our present forage cap, of which it is the prototype. In the field or in cold weather a slightly modified cap is issued in that service, provided with a hanging piece of thick material similar to the "havelock"; which, while usually buttoned up around the cap, may be turned down so as to protect the ears and neck. This Austrian service cap appears to be by far the best covering used in any European army, though very warm for hot weather.

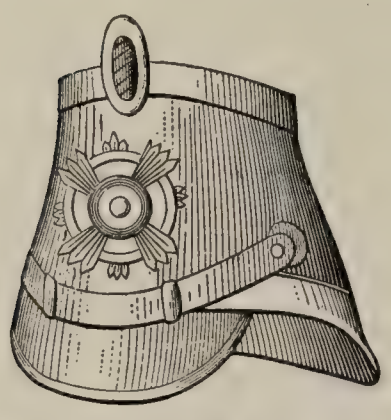


FIG. 101.—Types of Military Headgear. Shako.

The Outer Clothing.—The double-breasted overcoat with adjustable cape, used in both the foot and mounted services of our army, is made of sky-blue kersey and lined with dark-blue flannel. It is much too thin for use in extremely cold weather, absorbs much moisture and is difficult to dry when wet. It is slit up in the back to an extent of twenty-one inches, and since the skirts are thin they readily blow aside and afford little protection in strong winds. The collar is rolling and has a width of about three and one-fourth inches. It would be a much better protection if it

were about one and one-half inches wider. The lining of the cape varies in color according to the branch of the service. The cape itself is not sufficiently long to be of any great value as a separate garment; its use for this purpose being sanctioned by custom, if not authorized in orders. The overcoat should be amply provided with pockets; there being at present only a single inside pocket. It is of great importance that this overcoat should be rendered water-proof by the use of lanolin, so as to enable the poncho to be dropped from the equipment.

The British army overcoat is somewhat heavier than our own, weighing about six pounds. The Belgian overcoat is double-breasted; the skirts, as in other European services, being capable of being fastened back, upon the march, so as to leave the legs free. The Russian overcoat is also double-breasted and reaches about two-thirds the distance below the knee. The French, German and Austrian overcoats are similar but shorter. In the German army the collar may be held up, when required, by a little hood, which is concealed in a pocket in the collar when not in use. In cold weather or driving rain this hood can be put on underneath the helmet. This arrangement is excellent. In the Chino-Japanese war, the troops of the latter were provided with a great-coat of brown blanketing, with a hood and special covering for the head at night: It was comfortable, serviceable and of good color for field service. It came nearly down to the ankles, and was gathered at the waist by a broad band, the latter being an excellent protection for the abdomen and serving efficiently for the retention of warmth.



FIG. 102.—Uniform Overcoat.

The uniform blouse is made of dark-blue flannel, weighing thirteen ounces to the linear yard and capable of sustaining a strain of twenty-eight pounds per inch in the width of the warp; a better quality of material being issued for non-commissioned officers. It is a single-breasted sack coat with falling collar, and is provided with an inside pocket on the left breast. It is now supplied in nine sizes—made according to the following dimensions:

Sizes.	Length. Inches.	Length of sleeve. Inches.	Neck Inches.	Width of collar. Inches.	Breast. Inches.	Waist. Inches.
1	28	31	15	1¾	34	30
2	28½	31¾	15½	1¾	35	31
3	29	32¼	16	1¾	36	32
4	29¼	32¾	16½	1¾	37	33
5	29¾	33¼	17	1¾	38	34
6	30	33¾	17½	1¾	39	35
7	30½	34¼	18	1¾	40	36
8	30¾	34¾	18¼	1¾	41	37
9	31½	35½	18½	1¾	42	38

The blouse, as usually fitted to the soldier, is liable to compress the

muscles to some extent and to impede the respiratory movements of the chest. While it should follow the lines of the figure in a general way it should be made loose at the neck, large in the shoulder, chest and arm, and small at the wrist. Like the trousers, it should be sufficiently full to allow of the comfortable use of extra underclothing during very cold weather. The bottom should not be extended more than two inches below the great trochanter, and for cavalry an even shorter blouse or shell jacket is preferable. Coats with long skirts are worn only in the French and Italian armies, and possess no advantages over shorter garments where drawers are issued. The blouse used in the Russian army is made double-breasted. This garment should be made with four pockets, since these, in the field, can be used with great advantage by the soldier. In the Belgian army the breast pockets are utilized for the carriage of cartridges. A rolling collar does not sufficiently protect the neck in cold weather, and in all the great European armies, except that of France, a standing collar is worn. In the latter service an additional protection has been found necessary, and the wearing of cravats of blue cloth has long been required. A loose jacket, cut like the present issue of the khaki blouse, is the ideal military coat. Soldiers, who wear no waistcoat, should always keep the blouse buttoned, as much for the protection of the otherwise poorly covered abdomen as for purposes of military discipline and smartness. The buttons of the blouse should be made solid and not hollow, as is the case at present, and should not be of burnished metal.



FIG. 103.—Uniform Blouse.

The blue uniform trousers, excellent in character, are made from sky-blue kersey, weighing sixteen ounces to the linear yard and capable of sustaining a strain of fifty pounds to the inch in the width of the warp. In cut, the trousers should not be made high in the waist and should be loose about the hips and thighs. The legs should be cut proportionately narrower, and the bottoms should not be permitted to "flare," as is the preference of recruits; since such trousers cannot be readily stowed in boots or leggings and are more liable to become muddy and heavy in wet weather. If the trouser legs are made too long they are quickly soiled, become worn at the bottoms and chafe the lower limbs. Both hip and side pockets should be provided. In the French and Belgian mounted service the long Lasalle trousers are worn, the lower thirds of the legs of which are faced with sheep-skin to form false boots. These trousers have many disadvantages, and it is understood that their abolition in the French service is now contemplated.

Suspenders should be used in the military service in preference to the belt, and should be so colored as to present no great contrast to the uniform shirt with which they are worn. The belt compresses the abdomen, interferes with diaphragmatic breathing, favors constipation and is believed

by many to exert a considerable influence in the production of hernia. The belt and anything else the use of which disturbs a physiological function should have no place in the equipment of the soldier.

The uniform dress-coat is of dark-blue cloth, faced or piped with cloth of a color corresponding to the arm of the service or staff corps. It is a single-breasted frock coat, with standing collar, cut square to hook in front. There is a small inside pocket on the left breast. The dress coat is the same for the mounted as for the foot service, except that it is about three inches shorter and the skirts are slashed to within three inches of the waist. When donned, the skirts of the infantry coat reach to about the middle of the thigh. This coat is furnished, ready made, in six sizes. The dress-coat has no virtue except that of warmth, and its use should be abandoned. Made tight to impose an artificial stiffness upon the wearer, its use renders the soldier incapable of properly performing the very motions or duties for which he is specially trained and for which military forces are required. No man so dressed could either work or fight effectively, and it is to be hoped that the step in the right direction recently taken, in abandoning the dress-coat and uniform in the case of the hospital corps, will be followed by its abolition throughout the army at large.

Canvas suits are furnished in garrison for use by men engaged in fatigue. They are made of seven-ounce cotton duck, dyed in light brown. The coat is similar in cut to the uniform blouse, and is provided with breast pockets. These fatigue uniforms were largely used by the regular troops during the Spanish-American war, prior to the issue of khaki clothing, and proved far superior to the blue uniform for tropical field service. Similar fatigue uniforms are supplied in foreign armies.

Stable frocks and trousers of white duck have long been issued to mounted troops for the better protection of their clothing, and are excellently adapted to the purpose for which they are employed.

In certain southern posts a summer uniform of white cotton duck is issued. The use of this uniform at all times is permitted to the hospital corps on duty at post or general hospitals. In most foreign armies, as the German, the uniform clothing is never varied, winter or summer.



FIG. 104.—Infantry Dress Coat.

The Underclothing.—The flannel shirt appears to be very satisfactory for military use in all climates. Even in tropical countries it is preferred by the men to the cotton or charpoy shirt, since with its use chilling of the body is largely prevented. It is at present issued in two grades, of eight and ten-ounce flannel respectively. It is loose-fitting, with broad rolling collar and large breast pockets. In the field or on fatigue it may be worn without a coat, and barring its color it forms an ideal military garment. When intended to be worn in the tropics or with the khaki uniform it should preferably be made in gray or dusty-brown. As issued, the shirt

should be long enough to reach the middle third of the thigh and should be provided with cotton neck and wrist bands to prevent undue retraction and constriction by shrinkage. This garment does not readily show dirt, and hence in the field it is frequently not washed as often as desirable. When dirty and full of sweat the flannel is somewhat irritant to the skin and may then favor the occurrence of urticaria, eczema and furunculosis.

Three grades of woolen undershirts are issued in our service, known as light weight, light quality and heavy quality. They each contain sixty per cent. of wool and forty per cent. of cotton. A white cotton undershirt is also issued; this, like the woollen undershirts, being supplied in six sizes. Both quality and grades leave little to be desired. The equipment of the German soldier includes three cotton shirts; a recent order providing also for the issue of a simple knitted woolen shirt in winter. In the British service each man is required to possess two woolen shirts, while in the French army the shirts are of merino, containing one-third cotton and two-thirds wool.

Drawers are intended primarily for cleanliness and the prevention of chafing, and secondarily for the warmth of the legs and lower portion of the abdomen. In warm weather, where the blue uniform is worn, troops are inclined to avoid the use of drawers. During the march the dusty trousers, saturated with perspiration, soon become filthy and by their heat and coarseness irritate and chafe the unprotected legs, while in camp the disuse of drawers is liable to be followed by surface chilling and intestinal disorders. Hence drawers should be required to be worn under all circumstances; their use, if necessary, being forced by inspection by company officers. They are supplied in canton flannel and cotton jeans, being issued in five sizes. Those of the former material are cut too loose for the mounted service, and are liable to wrinkle and produce chafing and excoriations. They should be fastened at the bottoms with tapes rather than by buttons. Light drawers, made of balbriggan, should be issued. As a matter of fact, soldiers in garrison largely refrain from drawing underclothing from the Government and prefer to obtain more desirable underwear from outside sources. No drawers are issued to troops in the English and Spanish services; the French soldiers being allowed two pair of cotton drawers yearly.

In the late winter campaign in China the Japanese troops, in addition to the regular underclothing, were provided with paper shirts and drawers. These were worn in very cold weather, the former between the usual under- and overshirts, and the latter over the ordinary drawers, and were said to be very warm and comfortable. The Jaeger underclothing, used largely in the German army, is so woven as to be non-irritating to the skin, while the arrangement of the constituent hairs facilitates the removal of moisture.

As mentioned elsewhere, military clothing should be cut loose to permit, if occasion demands, of the wearing of more than one set of underclothing; since, as is well known, animal warmth is better preserved by the use of several garments than by a single one of their aggregate thickness, owing to the air confined in their various layers. During campaign an extra pair of socks, suit of underclothing and shirt should always be carried by the soldier.

Woolen abdominal protectors are issued in several foreign services.

They are used by the French troops serving in Algeria and at tropical stations, but are not worn by soldiers on home service. In the British army the constant wearing of the abdominal protector is required by regulation; obedience being enforced by frequent inspection and dereliction being followed by severe penalty. In the British service, however, no drawers are issued, and to take their place some adequate abdominal covering is required; but where long woolen shirts and drawers are worn, as in our army, such additional protection is neither necessary nor desirable. For the sick, or during epidemics of diarrhœa, cholera or dysentery, the abdominal band may be worn with advantage—but with healthy men, particularly in hot weather, it is a cause of discomfort and fatigue. If sufficiently tight to retain its position, the band interferes with the action of the abdominal muscles and with intestinal peristalsis, and thus largely favors constipation.

The Coverings of the Extremities.—Gloves are necessary in winter to enable the soldier, without danger of frostbite, to manipulate his weapons with precision. In our service a fur glove is issued for this purpose, but this is unnecessarily warm, bulky, and cumbersome except in very cold weather, and a medium weight glove should be provided. White cotton gloves are issued not so much for warmth, of which they possess little, as to improve the appearance of the soldier for parade or other ceremonial. Cavalry habitually wear gauntlets when mounted. In the French service the use of mittens is authorized for the colder stations. The Japanese troops use mittens made with two divisions; the forefinger being inserted in one, when desired, for the more ready use of the trigger of the rifle. In the Russian and German services the soldiers in winter wear woolen gloves fastened together by a cord which passes up through the sleeves and over the shoulders. This arrangement is excellent for the prevention of loss, especially liable to occur during winter campaign.



FIG. 105.—Cavalry Gauntlet.

The military stocking is an article which has not received the attention which its importance warrants. No stockings are issued in the Spanish, French and Italian armies, a fact to which the frequency of injuries of the feet in these services must be largely attributed. The use of stockings promotes cleanliness and prevents saturation and hardening of the shoe leather by perspiration—a potent factor in the production of excoriations. In winter, also, the soldier, in rain or snow, with shoes often penetrated by icy water, is very liable to frostbite; this accident being in great part avoided by the use of woolen socks. In the war of 1870–71, cases of frostbite of the lower extremities were extremely common among the French troops, who had no protection for the feet other than leather shoes of notoriously poor quality; while freezing of the lower extremities rarely occurred in the German army, each soldier of which was provided with two pair of knitted woolen stockings. The annual clothing allowance of the British army includes three pair of woolen socks per man; the Swiss soldier yearly receiving two pair. In the German army stockings are only used in winter; pieces of cloth about fifteen or twenty inches long and four inches wide, which the soldier wraps around his feet, being issued for

summer use. These strips, or "Füsslappen," are made of linen, canton flannel or knitted woolen material, varying with the temperature and the moisture of the feet. They are applied by starting one end smoothly under the ball of the great toe and winding like a bandage over the back of the foot from within outward, finally covering the heel, while the last corner is laid smoothly across the instep. In the Russian army such strips are worn throughout the year, the company officers being responsible for their cleanliness and proper application. These pieces of cloth are merely economical makeshifts for better articles, but their use does not appear to be as detrimental to the integrity of the feet as at first sight would seem to be inevitable. It is claimed for them, as compared with stockings, that they can be more readily washed and dried, take up less room, and, by being folded in different ways, are worn out more uniformly and less quickly. To take the place of stockings the French soldier, during the war of 1870–71, often filled the vacant space in his shoes with straw.



FIG. 106.—Woolen sock.

In our own service both woolen and cotton stockings are issued, the latter being provided in two grades and five sizes. The woolen sock is made of pure wool and is furnished in three sizes; size ten and one-half being required to weigh three pounds per dozen pairs. These socks should be issued in at least six sizes, since when ill fitting they are provocative of corns and blisters. If too small, the toes are cramped and the wearing out of the material is hastened; if too large, the stocking is apt to wrinkle at the heel and so induce the occurrence of blisters. To prevent the latter accident the sock should be held up, preferably by pinning to the drawers—but the use of garters is objectionable in that they bind the leg and favor the occurrence of varicose veins. The wearing in the field of stockings which have been worn through or darned should always be avoided, and before entering upon a campaign the kit of the soldier should be inspected for their elimination. Given the most perfect shoes, if a man has a hole in his sock his foot will be inevitably blistered, and in this connection it may be emphasized that the rough-and-ready darning usually given these articles by the men is nearly as bad as the holes themselves. Woolen stockings, the only kind issued in foreign armies, and until quite recently in our own also, induce free perspiration of the feet, but are much more suitable for the use of troops in the field during the march, as being less liable to induce chafing. They should, however, be changed on arriving at camp, and their use necessitates even greater attention to the cleanliness of the feet. With a heavy stiff shoe a thick soft stocking is practically a necessity for constant marching—a fact throughly recognized by old soldiers.



FIG. 107.—Cavalry Legging.

Leggings, made in three sizes of fifteen-ounce brown canvas duck, to be worn in the field or on campaign, are now issued to all branches of the service. They are a great protection for infantry, particularly in wet weather or when campaigning in a rough or timbered country; and since their adoption our foot-troops have been freed from the necessity of facing their trouser legs with canvas or buckskin, as was formerly customary in frontier service, to prevent their being worn out or cut by grass, brush or briars. For cavalry the legging is a marked improvement over the boot, since it answers every purpose when mounted, is light and pliable, and, if on dismounted service, does not impede the performance of any duty. Leggings are much liked by the troops, since they protect the legs, prevent muddying of the trousers, promote cleanliness and dryness and are readily cleaned at the end of a march. Their disadvantages are those of extra articles of clothing to be looked after, together with their slightly additional weight. If worn too tight they bind the muscles of the legs and thus may considerably increase the fatigue of the march; for this reason shorter leggings are desirable for foot troops. While the strap passing under the instep promotes smoothness of the legging over the shoe, in a muddy country it is a serious disadvantage through the mud which it collects. In this respect it is a question whether the English style of legging is not superior to our own.

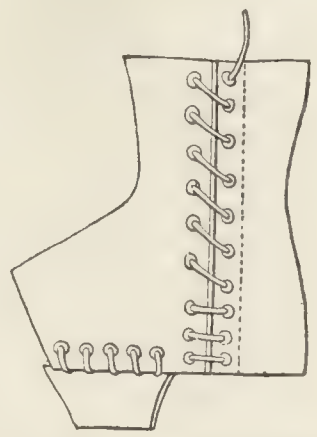


FIG. 108.—Legging Used in Italian Army.

The Italian infantry wear short linen leggings or gaiters; while in the Japanese service a legging of white canvas, similar in cut to our own and reaching nearly to the knee, is worn by the foot troops. Long leggings made of leather are used in the British army —though recently "putties" have been much used—and in the Austrian service the half-boots formerly worn by troops have been replaced by shoes and leggings. No leggings are used in the German or Russian armies; but boots are used, and the trousers tucked into them before beginning the march. In India, "putties" are used instead of leggings, both by foot and mounted troops, and are said to be satisfactory.

It will not be disputed that the marching powers of infantry are a most important factor in the conduction and success of a campaign, and that the army which marches best, other things being equal, is the successful army. History is full of instances where battles and campaigns have been won more by marching than by fighting, and rapidity of movement will be no less an element of military strategy in the wars of the future than it has been in the past. Napoleon is reported to have said that he made war not so much with the arms as with the legs of his soldiers; while Marshal Niel considered good shoes for his infantry as important as mounts for his cavalry. Saxe said that the whole of military tactics was in the legs of his soldiers—and Wellington enumerated the three most essential parts of the soldier's equipment as a pair of good shoes, a second pair of good shoes and a pair of half-soles. Hence it is that of all the protective coverings which the foot-soldier wears, his shoes are by far the most important from a strategic standpoint; since upon their ease and the comfort of their fit, their pliancy and lightness, depends his military efficiency. War

is a business, and the soldier whose badly-shod feet are unable to carry him into battle fails of the purpose for which he was trained—and instead of being an added strength he becomes an incumbrance. Lindau, in 1883, found that of ten thousand men discharged annually from the German army for physical disability, in time of peace, four hundred were for affections of the feet—a proportion which would be greatly increased in time of hostilities; while, as stated in a previous chapter, over thirty thousand German soldiers were incapacitated for duty during the first few weeks of the Franco-Prussian war on account of injuries of the feet—these having largely resulted from the use of poor foot-wear, hardened by long storage in the supply depots. Léques, in 1882, found that excoriations of the feet figured as one-third of all the causes of exemption from active service among young French soldiers during campaign.

In character, the military shoe should afford the greatest amount of protection with the least injury to the foot of the wearer. It should possess solidity and rigidity, yet at the same time have a certain amount of suppleness. It should protect against the cold in winter, against heat in summer and moisture at all times. Evaporation of perspiration should be readily carried on. The shoe should be so fashioned as to be readily donned and removed, and should be light in weight. The importance of light foot-wear for the soldier is so fully appreciated by the Germans that even the nails of the military shoes are made of aluminum in the effort to reduce weight. According to Viry, "each gramme more or less on the shoe is equivalent, so far as the effect on the wearer is concerned, to one kilogramme more or less to carry through the journey." The shoe should also be made of durable material presenting no interior roughness, should be reasonably cheap, and should be supplied in such a variety of sizes as to render the fitting of the foot a matter easy of accomplishment. In fashion, custom should be disregarded for utility.

The sole should conform in shape to the natural outline of the foot; the outer margin of which is a long curve, while the inner side approaches a straight line. Ample space for the fifth metatarsal should always be ensured. The toe should be slightly rounded, the point being toward the inner aspect rather than in the centre. The fore part should be broad to allow for expansion; but no great breadth is necessary at the middle of the foot, which does not spread to any extent. To protect the sides of the foot against stones, the sole should be wider than the uppers by about one-eighth of an inch; but if it project too far it serves to accumulate mud, and thus increases fatigue in marching over muddy roads. The sole should be supple, since if it be too thick flexibility is lacking, while if thin the protection is insufficient and the shoe lacking in solidity. The insole should be smooth and slightly concave to receive the heel and ball, but there should be no contact or interference with the free play of the ankle, which is intolerant of support except at its extremities.

The heel should be fixed in such a manner that it cannot be detached. It should be broad to afford a solid base, and low to prevent the sliding forward of the foot, with resulting discomfort and cramping of the toes. The length of the pace as well as the stability of the individual is directly influenced by the height of the heel—and it may fairly be questioned whether the actual omission of the latter, as is done in the Greek army,

may not be of advantage. For the erect and artificial gait of civilized peoples the use of the heel is, no doubt, largely responsible, and with its retention the successful use of the natural or aboriginal gait, described in a previous chapter, will be accomplished only with some difficulty. To diminish the vibration of the body, particularly that of the encephalon, produced by the impact of the foot upon the ground, Collin proposed to make the heel of rubber. He claimed as a further advantage for this device that the energy stored up in the rubber compressed by the weight of the soldier would assist in his propulsion. Trial of such a shoe in the French service has appeared to result favorably, it being found that the same effects can be produced by a disc of rubber inside the shoe just above the heel.

For field service the heel and such part of the sole as touches the ground in walking may advantageously be fortified with hob-nails or strips of leather; thus adding to their durability and giving better foothold, particularly on grass or rough or frozen ground. They should not be too many in number and should be firmly fastened and not liable to fall out, since when the latter occurs the sole ceases to be water-tight. In the German service these nails and those used in fastening the heel are made of aluminum to diminish their weight. Metal plates, sometimes advised, take up much of the wear, but are heavy and soon become smooth and polished, causing much discomfort and fatigue to the wearer through the insecure foothold given.

There should be no surplus leather in the upper, nor should it possess interior seams to bruise and abrade the skin. The instep should be high, for if it is not the men will frequently cut the vamp and tongue, thus destroying the support to the ankle and injuring the appearance. The leather around the ankle joint should be light, to provide for the rocking motion of the foot, yet should fit snugly. The tongue should be of the bellows style, and the top of the shoe should be cut high. The shoe should be hollowed out behind to prevent friction of the heel. The method of fastening should be easy and simple—the use of lacing best filling this indication, as well as allowing ready adjustment to the swelling of the foot on the march.

The shape of the foot at rest differs from that of the foot in action. In the normal adult foot the weight is supported on the outer border of the sole, the heel and the anterior extremities of the metatarsals. The toes bear little weight when standing, more when walking and most of all when running. The great toe is a direct prolongation of the first metatarsal, and its single joint is acted upon by the strong flexor muscle, which, in propulsion, tends to shorten the foot and preserve the plantar arch as well as to approximate the inner side of the foot to a straight line. This bow-string effect of the flexor tendons does not begin until the body is in advance of the vertical line and reaches its maximum at the end of the step. Pressure increases the length and breadth of the foot at the first part of every stride, through the yielding of the arch and the spreading of the structures, while swelling occurs as the result of long marches. The greater spreading occurs in the toes, the ball widening 6 to 12 mm., the instep still less, and the heel only flattening to meet and adapt itself to the supporting surface. Feré found that, as a result of long marches un-

der heavy equipment, the plantar arch tends to become obliterated, with resulting temporary flat-footedness.

In dealing with the feet of the soldiers, these may be regarded as being physically a select class from which at the outset many common abnormalities are excluded, although most feet are more or less deformed by the custom of shoe wearing. As a result of the pressure of ordinary shoes, a line drawn from the centre of the heel to the tip of the great toe will usually not cut the latter, but will pass through the third metatarsal, practically dividing the foot into halves and depriving the inner aspect of the leverage of the great toe, which has been displaced toward the centre. This toe may be semi-dislocated, often with the production of an inflammation in the joint, while its nail, turned down by pressure, is prone to grow into the flesh. The second and third toes, pressed together, are raised up, and examination of the sole of the foot shows only the third, fourth and great toes. Through pressure the toes are atrophied and deformed, loosing their rounded appearance and becoming asymmetrical and prismatic. If the shoe is too short they are retracted and take on the appearance of "hammer toes," which deformation gives great pain and unfits for marching. The tarsal bones are often deformed and present exostoses. The ordinary last upon which the issue shoe is made does not make provision for the comparatively large size of the great toe, especially over the joint, is not sufficiently full over the other toes, and the upper leather over the heel and tendo Achillis is cut too straight; hence it is at these points that excoriations and blisters most frequently occur. Deformities of the feet which are not very great are overcome by the use of rational shoes and need not be considered as necessarily a bar to enlistment.



FIG. 109.—The Normal Foot and Foot-print.



FIG. 110.—Deformities of Feet Resulting from Bad Shoes.

Soldiers, if left to themselves, are prone to draw shoes too short and narrow for their weighted feet, and the officer witnessing the issue should always pay particular attention to the selection made. It would be of advantage if all shoes drawn were put on by the men immediately on returning to barracks, and their fit verified by the company commander before actual use. In fitting the shoe, one-tenth should be allowed in length and

slightly less in breadth for the expansion of the foot in locomotion. Ziegler fixes the necessary excess of length at 15 to 20 millimeters.

The carriage of an extra pair of shoes during campaign is a severe tax on the energies of the soldier, and it is a much-mooted question whether it is not advisable entirely to do away with this practice and trust to issues in the field from time to time, as opportunity permits, to replace deficiencies. Such an arrangement, however, would also do away with one of the most efficacious methods of preventing injury to the feet by marching; namely, the use of two pairs of shoes in daily rotation, by which relief is afforded through the temporary removal of pressure from galled places and its transference to other less sensitive parts.



FIG. 111.—Radiograph of Foot of Soldier, showing deformity of toes and irritation exostoses due to bad shoes.

During hard campaign, with constant marching, under usual conditions of moisture and roughness of roads, a pair of shoes may be expected to last about two months, and be sufficient, with light repairs, for a journey of six hundred miles over ordinary terrain.

It is of the greatest importance that shoes which are new and stiff should be carefully suppled and broken in before being used on the march, since otherwise injury to the feet is almost certain to result. Such footgear should be soaked in water until every part is pliable, donned while wet over a heavy pair of socks and used for a walk of several hours. They will be found comfortable from the start, and at the end of that time will have acquired the exact shape of the feet. The shoes should then be removed, tightly packed with dry oats and set aside in a cool place so as not to dry too rapidly. When finally dried, the seams should be coated with molten wax to protect the thread, without removing the oats, and the whole outside should be given a coat of neatsfoot or cod-liver oil, repeating several times, and finally completing the process with some water-proofing dressing. The oats are then shaken out, and the shoes will be found to be comfortable, damp-proof and durable, since the swelling of the oats prevents shrinkage and no last can mould the inside of the shoe like the foot itself. Shoes which have been kept long in store become hard and inflexible, to prevent which they should, from time to time, be well gone over with an oiled rag.

Wet shoes are heavy, liable to chafe the feet and readily lose their

shape; and the military shoe, while permeable to air, should not readily admit water. To assist in keeping out dampness it has been suggested that a layer of gutta percha be put on the upper part of the sole before it is sewn in place, but this is undesirable on account of the retention of the perspiration which is thus caused. The uppers should in all instances be waterproofed; this procedure not only ensuring dryness of the feet, but also suppling of the leather and rendering it more durable and readily cleansed. An excellent waterproof paste, which does not prevent the blackening of shoes, is composed as follows:

Tallow	6 parts.	Linseed oil	2 parts.
Wax	2 "	Venice turpentine	2 "

This should be applied slightly warm.

Thomas' preparation is similar, containing:

Mutton tallow	6 parts.	Neatsfoot oil	1 part.
Yellow wax	1 "	Venice turpentine	1 "
		Paraffine	1 "

In these formulæ the wax and paraffine are undesirable, since they interfere with the dissipation of perspiration from the feet. Salquin recommends the use of the fat of the horse as being best of all; the writer has used wool-fat successfully. In the French army a mixture of three parts of mutton tallow to seven parts of neatsfoot oil is employed; the proportion of tallow being slightly diminished in cold weather. Tanners use a mixture of mutton tallow, cod-liver oil, and a little potassium, this being worked in with a cloth and the aid of gentle heat. In the absence of the issue of any special preparation for this purpose, old soldiers are careful to frequently rub their shoes, previously warmed, with bits of fat bacon from which the salt has been dissolved, this increasing the impermeability and pliability of the shoe. Shoes thus treated, however, soon acquire a bad odor and attract flies in hot weather, and the rancid fat is said to cause rotting of the thread. Shoe blacking, as generally employed, contains a certain amount of sulphuric acid, which induces drying and deterioration of the leather and predisposes to cracking, the rotting of stitches and the entrance of water. Hence the military shoe should preferably be greased rather than blackened, especially since the blacking of shoes interferes with the evaporation of perspiration. To avoid the necessity of blacking the shoes, with its several disadvantages, the boots issued in the German army are now made of fair leather. Shoes of this character, as issued with our khaki uniforms, have been much appreciated.



FIG. 112.—United States Army Regulation Shoe.

The United States army shoe, as adopted in 1898, appears to be excellent and satisfactorily to fill the needs of the military service. The vamp is made of calfskin, and the top and tongue of kangaroo calf,

boarded and of uniform thickness. The side lining is the same material as the vamp, while the upper lining is of shoe drilling. The outsoles, top piece and heel lifts are required to be cut from best quality hides weighing eighteen to twenty-six pounds to the side. The shoe is hand-sewed with silk and linen thread, the inseam being covered by a welt taken out of the insole to protect the seam and make it level for the wearer. The outsole, thoroughly hammered, is grooved one-sixteenth of an inch to countersink the stitching, and sewed with eight and one-half stitches to the inch. The shoe is issued in eight sizes and four widths; the weight two and one-half pounds per pair. This shoe is constructed of excellent material and well answers the purpose for which it is intended.

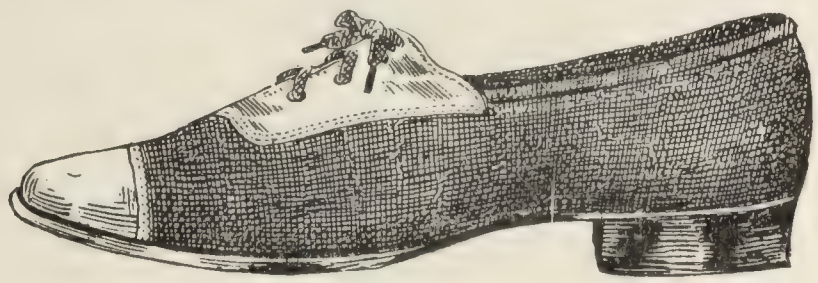


FIG. 113.—United States Army Barrack Shoe.

Constant watchfulness on the part of quartermasters is necessary to keep the quality of leather used up to the proper standard. All leather must have the entire thickness of the hide, as the middle portion is fibrous, absorbent and tough, and cannot be permanently reduced to a smooth surface. When subjected to hard wear it soon becomes rough and cloth-like in appearance. A too cheap shoe is never an economy, and footgear pegged or poorly stitched, whose absorbent soles almost fall apart upon exposure to wet, are plainly always to be avoided.

Barrack shoes are issued for use in garrison when not on duty, and are much lighter and more comfortable than the leather shoe for this purpose. They are made with uppers of fifteen-ounce brown cotton duck, the toe and top of vamp being made of russet-colored calfskin. In the British service a stout water-proof slipper, and in the Austrian and German armies a low shoe, forms part of the field equipment of the soldier and is intended for use in the camp after conclusion of the march. This practice does not seem to have any positive advantage over the carrying of a stouter and heavier shoe, since excellent results can be obtained by changing the ordinary shoes and stockings after the march, the difference in weight being of little importance when compared with the military advantage of having a second marching shoe always available.



FIG. 114.—Cavalry Boot.

In our mounted service a riding boot, issued in three widths and eight sizes, weighing about four and one-half pounds, forms part of the uniform of the soldier. This boot is well made, but is comfortable only for mounted use and is very liable to chafe when walking. If loose-fitting, it affords no support to the ankle, and the liability to excoriation is proportionately increased. If snug, it is not easily put on or taken off, and if the leather be wet or shrunken, the stocking damp or the foot swollen, the former action is at times impossible. Under all circumstances the boot gives an insecure footing on a grassy surface, while it forms an insufficient protection in cold weather and is uncomfortably warm in hot climates. If boots must be worn in

the future they should be short, pliable and light—but their use, together with the helmet and dress uniform, should preferably be abandoned. All mounted troops spend more time on foot than in the saddle, and since the Civil War our cavalry has fought dismounted. Hence it is only logical that the footgear of the cavalryman should be such as would enable him readily to march or perform any other duty when dismounted through accident or design, and for this purpose no better combination than the infantry shoe and long canvas legging can be devised. For purposes of parade a detachable leather leg, with stiff brace, might be worn with the shoe; thus giving all the effect of the boot and still avoiding a large proportion of its disadvantages.

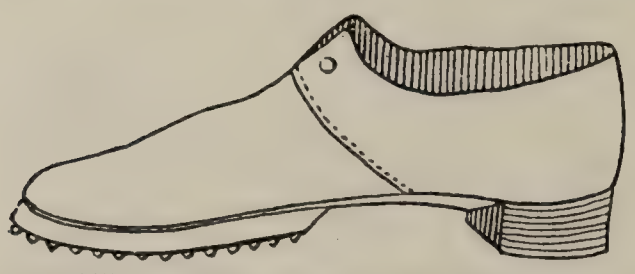


FIG. 115.—Low Shoe Used in the Italian Army.

The footgear worn in different foreign armies varies greatly. In the Greek army a foot-covering similar to the buskin or high moccasin is worn. The Italian and Belgian soldier wears a low shoe and gaiter of the style discarded in France several years ago. The Spanish army in garrison uses laced leather shoes—but in the field it is supplied with sandals having rope soles, the latter rapidly wearing out and being of but little protection in mud, water or snow. In the British service a high laced leather shoe, with leather leggings, is worn. In the French army the "brodequin" or modified shoe has recently been adopted and gives excellent satisfaction; footgear of this type being worn also by the troops of Austria, Switzerland and Turkey. In the German and Russian services the soldier wears a boot; this having obvious advantages in rain or snow, but possessing also many of the defects above noted for our cavalry boots. The Russian boot is also higher than would seem to be desirable, reaching to just below the knee.



FIG. 116.—French Brodequin.

The Blanket.—Excellent gray blankets are issued to troops, and of these each man possesses at least one. The specifications require that this blanket be made of long staple wool, free from shoddy, re-worked wool or cotton, and capable of bearing a strain of not less than thirty pounds per inch without tearing. The blanket is seven feet long and five feet six inches wide, and is required to weigh not less than five pounds. When in the field, and circumstances require it, an extra blanket for each two infantrymen may be carried on the wagons if transportation be ample. Should bad weather render it necessary, each mounted soldier may make use of his saddle blanket in addition to the one carried for his own protection and comfort. Where used alone, the blanket may advantageously be converted into a sleeping-bag by sewing up one end and continuing the process half way up the side. The writer has found that the best plan for cold weather is for two men to sleep together, spreading their blankets lengthwise in such a way that the overlapping longitudinal edge of one corresponds with the middle line of the other. The men lie down close to each other

in the centre of these blankets, and by pulling the free ends of the blankets over them convert the latter into a sleeping-bag having a double thickness above and below. The open end at the foot is closed by lifting it up by the feet when the men are in position and turning in the upper edge. The feet rest on this edge, and their weight holds it in position, making the sleeping-bag wind-proof. Where this method is frequently employed it is well to work a small buttonhole in the corner of each blanket and sew a button at each end of the horizontal bisecting line more securely to fasten the blankets in position. The blanket, like the overcoat, should always be water-proofed for better protection against damp ground or surface moisture. When once wet the non-waterproofed blanket is uncomfortable at night and burdensome by day, and frequently cannot be dried in the field during a period of rainy weather.

The rubber sheet serves an excellent purpose in protecting the sleeping soldier from soil moisture. It is six feet long and three feet nine inches in breadth, and weighs two and one-half pounds. It is furnished with brass grommets so situated as to enable several of the water-proof sections to be joined, or to permit its use for the protection of the person of the soldier in camp or on the march during rainy weather. For ordinary use the rubber blanket may conveniently be replaced by the poncho; this having a central perforation which passes over the head and retains it in position without assistance from the hands. It affords excellent protection from rain during the march, and has the great advantage of not interfering to any great degree with the circulation of air. Where the ordinary clothing is properly water-proofed according to one of the methods already detailed, however, the use of ponchos and rubber blankets can be very well dispensed with, and a saving thus made in the weight carried by the soldier. Ponchos and rubber blankets are issued gratuitously and are not charged against the soldier unless lost or destroyed by his neglect.

II.

EQUIPMENT.

Transportation upon the person of such articles as are considered necessary for the independence of the modern soldier in the field, is to be accomplished only with great personal discomfort and fatigue, and often by the expenditure of so much vital force as to seriously affect efficiency and health.

Weight.—The United States foot-soldier is required to carry in the field, besides the clothing worn on the person, the arms and ammunition, the canteen, the ration and the utensils for its preparation. To this may be added the change of shoes and underclothing, the blanket, poncho and shelter-tent half. With small columns these latter articles are generally transported in the wagons, but with large commands each man must carry his own. How this may be done without undue discomfort and fatigue to the soldier, and how the present burden may be properly reduced, are problems important from the tactical as well as the hygienic standpoint which are as yet awaiting satisfactory solution.

Outside the armament and equipment, the weight carried by the individual naturally depends upon climate, season and the number of rations which it is required to transport. In hot weather the overcoat and heavy clothing are obviously unnecessary, while in dry climates the rubber blanket and even the shelter-tent may often be dispensed with to advantage. While the determination of the articles to be borne by the soldier in the field has, in the past, been left largely to the commanding officer in each individual instance or emergency, it is probable that only in rare instances—as in a winter campaign in a cold climate, when transportation is deficient—will the maximum outfit authorized by regulations be carried.

It is not possible to state in exact figures the burden to be transported by the individual—since the weight of the clothing varies according as the articles are wet or dry and also with the height and size of the wearer—but the maximum weight which may be carried under ordinary conditions can be considered to be made up as follows:

Apparel Worn on the Person.

	Pounds.	Ounces.
Campaign hat	—	5
Overcoat	6	6.75
Blouse	2	1
Knit drawers	—	14.75
Trousers	2	.50
Suspenders	—	2.50
Flannel shirt	1	3
Knit undershirt	1	2
Stockings, woolen	—	4.75
Gloves, fur	—	10
Shoes	2	7
Leggings	—	8.50
Total	18	1.25

Armament and Equipment.

	Pounds.	Ounces.
Rifle	9	5.50
Gun sling	—	5.25
Bayonet	—	15
Bayonet scabbard	—	8
Cartridge belt, woven	1	4
Cartridges, 100	6	4
Blanket bag	1	10
Blanket bag, shoulder straps, pair	2	1
Blanket bag, coat straps, pair	1	14
Canteen	—	14.75
Canteen strap	—	6
Haversack	1	—
Haversack strap	—	6.50
Tin cup	—	6.25
Meat can	—	14.75
Knife	—	2.12
Fork	—	2.13
Spoon	—	1.50
Total	28	11

Equipage and Additional Clothing Carried by the Soldier.

	Pounds.	Ounces.
Drawers	—	14.75
Undershirt	1	2
Flannel shirt	1	3
Stockings	—	4.75
Towel	—	3
Shoes	2	7
Trousers	2	0.50
Poncho	2	12
Blanket	5	—
Shelter-tent half, with poles and pins	3	—
Total	18	10

Rations which may be Carried by the Soldier (Three Days).

	Pounds.	Ounces.
Bacon	2	4
Hard bread	3	—
Coffee, roasted	—	4
Sugar	—	7
Salt	—	2
Water carried in canteen (full)	2	12
Total	9	0

Summary.

	Pounds.	Ounces.
Clothing worn on person	18	1.25
Arms and equipment	27	12
Rations, three days	9	—
Equipage and additional clothing	18	15
	73	14.25

To this may be added the personal accessories, such as soap, comb, tobacco, matches, pocket knife and money, weighing approximately one pound, making seventy-four pounds fourteen and one-fourth ounces the maximum allowance to be carried by the soldier.

According to Kirschner, the maximum weights to be carried by the infantrymen of different foreign armies, in 1893, were as follows:

	Kilograms.	Pounds.
Italy	33.000	$72\frac{1}{2}$
Germany	32.427	$71\frac{1}{2}$
Switzerland	30.375	$66\frac{4}{5}$
France	29.555	65
Russia	29.506	65
Austria	29.480	$64\frac{4}{5}$
England	28.622	63
Belgium	28.000	$61\frac{1}{2}$

Since these figures were given it is understood that the weight of the equipment in the French and German armies has been gradually reduced, through the omission and lightening of articles and the use of aluminum, to 26 kilograms in both instances.

From the above figures it requires no argument to demonstrate the fact that the weight to be carried by the soldier in nearly all countries is in excess of the practical as well as the theoretical maximum, and that fur-

further reduction is desirable for hygienic as well as tactical reasons. Heavily loaded troops can march neither rapidly nor to any great distance, and the aggregate strength is proportionately weakened by the carriage of every superfluous article; for the men who do the fighting are those who keep well up in the ranks. The carrying of the equipment was estimated by Lewal to deprive the soldier of one-third of his mobility; he believing that the traversing by the French soldier of 40 kilometers in heavy marching order entailed the expenditure of as much energy as a march of 60 kilometers without such burden. Thurnwald states that the soldier should not carry a burden greater than one-third of his own weight if it is desired that he should maintain reasonable freedom of action on the march and in battle. Since many young soldiers do not weigh more than 50 to 60 kilograms (130 to 135 pounds), he estimates that the total weight of the clothing and equipments should not exceed 20 kilograms (45 pounds). According to Laveran, experiments made recently in Germany with marches of 25 to 28 kilometers and weights of 22 to 31 kilograms, under varying conditions of temperature, showed that with a burden not greater than 22 kilograms and a distance not greater than 25 to 28 kilometers, such a march in an average temperature might be considered purely as salutary exercise. In hot weather these same conditions gave rise to unfavorable symptoms; which, however, disappeared after a few hours' rest, without bad results. With a weight of 27 kilograms, during marches of a similar length, if the weather was cool and favorable no bad effects were noted, but if, on the contrary, the march was made in hot weather, very serious symptoms resulted. These experiments showed that a weight of 31 kilograms (68 pounds) is much too great to be carried under any circumstances. Laveran places a weight of 27 kilograms (59½ pounds) as the maximum burden for marches of 22 to 28 kilometers during warm weather in temperate climates. These figures would seem to be too high, and for such conditions anything over 50 pounds is probably excessive.

Prolonged marching under too great burden has been found to induce a gradual weakening of the constitution of the soldier, analogous to the lassitude and loss of muscular tone observed in over-trained athletes, and this systematic depression plays an important part in favoring susceptibility to infectious disease. It is a matter of common knowledge in European armies that increase in the sick-rate follows the autumn manœuvers; this being largely attributed to the more ready infection depending upon the exhaustion following the severe marching under heavy equipment which the troops are forced to perform.

Reduction of Weight.—Napoleon believed in reducing the equipment as much as possible, but named the weapon, cartridges, knapsack, four days' rations and the pioneer's tools as the five things which should never be separated from the soldier. As to additional articles, he believed that the soldier in the field could do well with a spare shirt, extra pair of shoes, stock and kerchief comprising his equipment. At present, such an outfit would be regarded as wholly insufficient.

Where the soldier carries his own equipment, the multiplication of articles for his comfort or efficiency is highly inadvisable, since, beyond a certain point, the inconvenience of weight far overbalances the advantages of possession. The allowance of the soldier, while containing the neces-

saries, should not include a single article not absolutely required; the tendency properly being to diminish the equipment, both in weight and number of parts, rather than to increase it. When rapid or forced marches are required, the soldier will usually march with no burden except the clothing worn on the person, the armament and necessary rations. The weight of the latter should be reduced where possible by the use of emergency rations, and these may profitably be transported by the soldier only when the necessity for their possession is imminent; at which time they should be served out from the wagon train or depot.

In reducing the weight of the equipment of the United States soldier the extra pair of trousers may advantageously be removed from the list of articles already given. The carriage of an additional pair of shoes is a severe tax on the strength of the soldier, and, where communication with the base of supplies is excellent, they, too, may perhaps be subtracted from the burden to be carried. The poncho may frequently be omitted, particularly if the outer clothing has been water-proofed. The overcoat is necessary only in cold climates and for about one-third of the year, and the same applies to heavy-weight clothing and underclothing. This places the minimum weight to be carried by the soldier in the field, in temperate climates, as follows:

	Pounds.	Ounces.
Clothing on the person	10	—
Armament and ammunition, 100 rounds	18	10
Carrying apparatus (exclusive of blanket bag)	4	6
Water and rations for one day	3	8
Blanket	5	—
Shelter-tent (without poles or pins)	2	8
Undershirt	1	—
Overshirt	1	—
Drawers and stockings	1	—
Small articles	1	—
Total	48	—

Or, less the ordinary clothing, about thirty-eight or thirty-nine pounds. While this is not a heavy weight to lift, it is certainly a very heavy weight to carry for a day's journey of fifteen to eighteen miles, and yet must be considered as light when compared with the usual equipment carried by the soldiers of foreign nations. With the allowance as enumerated above the soldier will be comfortable in warm and dry seasons, and need suffer no great hardship even during comparatively inclement weather. The further decrease of the clothing and equipment to thirty-seven pounds is possible; but this necessitates the abandonment of all but the clothing worn on the person, the armament, ammunition and rations. Such reduction, however, is rarely advisable from a tactical point of view and never from that of hygiene, since, when deprived of his blanket roll, the soldier is exposed to all the vicissitudes save that of hunger, and even under the best of circumstances cannot long maintain his military existence. On this account it is dangerous to abandon even temporarily the equipment on going into action, since, if defeated and forced to retreat, disorganization the more certainly follows. This, however, is one of the fortunes of war which military commanders will probably continue to hazard.

Diminution in the number of articles composing the equipment, if ex-

tra clothing is to be carried, seems scarcely possible under present conditions, particularly in cold weather. For reduction of weight the next most promising field lies in the substitution of aluminum for other metals wherever possible, this readily permitting a decrease of weight amounting to about two pounds. Such a possible reduction, though at first thought apparently of but trifling importance, would nevertheless conduce greatly to the comfort and efficiency of the soldier—for two pounds carried twenty miles implies the expenditure of energy equal to that required to transport forty pounds through one mile. It should not be forgotten, however, in this connection, that the adoption of a small-caliber rifle, by which the weight of the individual cartridge was reduced, was hailed with delight by the tacticians, who, instead of regarding the reduction in weight as a gain in efficiency of the soldier, proceeded to bring up the burden to its original weight by more than doubling the amount of ammunition to be transported. Hence it is not improbable that the accomplishment of further reduction in weight would simply serve as a pretext for the addition of other articles, the carriage of which by the soldier is at present confessedly impossible. The French have endeavored to reduce weight by abolishing individual camp utensils and issuing somewhat larger ones to each group of four or five men. This plan, while of advantage in a service where soups and stews form the chief food of the soldier, and where bulky kettles are consequently required, would obviously not be advisable in connection with a ration composed as is that of our army.

In considering the reduction of the equipment, it is well to remember that the soldier, particularly the recruit, starts out on campaign with the full authorized allowance, including duplicates of most garments, and is also prone to add various smaller articles which are fancied to be necessary to comfort. These latter should be carefully eliminated by inspection of the outfit before taking the field, and the soldier restricted to the official allowance; the latter also being advantageously diminished when circumstances warrant the removal of such articles as may not appear to be essential. With hard marching, however, the soldier is apt to take the other extreme and lighten his load at the expense of even the more essential articles, trusting to good fortune to supply the deficiencies thereby created. This tendency, like that of overloading, is a marked characteristic of raw or ill-disciplined troops and should always be rigorously repressed.

Disposition of the Equipment.—The greatest care is necessary in adjusting the burden of the infantry soldier, common experience showing that the transportation of the equipment is more or less fatiguing and injurious as it is carried in one or another manner. In practice, it is probably not so much the actual weight as it is the arrangement of the effects which is oppressive to the soldier.

The effect of heavy burdens, tight clothing and poorly distributed and disposed equipment in the production of heart-strain, as noted elsewhere, has long been understood—the mode of action being analyzed by Taylor as follows: The tightly buttoned coat, cartridge belt and gathered trousers compress the waist and thorax, and thus impair the movements of the diaphragm and of costal expansion. The weight of the gun and equipment holds the shoulders back, impedes motion of the upper portion of the chest, and with this arrest of the respiration there is an impairment of the circu-

lation of the blood through the lungs; hence there is an accumulation of blood in the right heart and venous system which extends to the venous radicles and capillaries. The burden thrown on the right side of the heart is too much for it, and hence there is a lessened amount of blood sent to the left ventricle, which diminishes the amount sent through the coronary arteries for its own support as well as the amount sent to the nervous centers. Therefore, the nerves and heart fail for want of nutrition and support. In time of war the stress on the heart becomes greatly increased. Additional burdens are carried, and these, together with rapid marches, deployments, alignments, and the bodily fatigue and great mental strain incident to battle, powerfully affect the heart to its permanent injury.

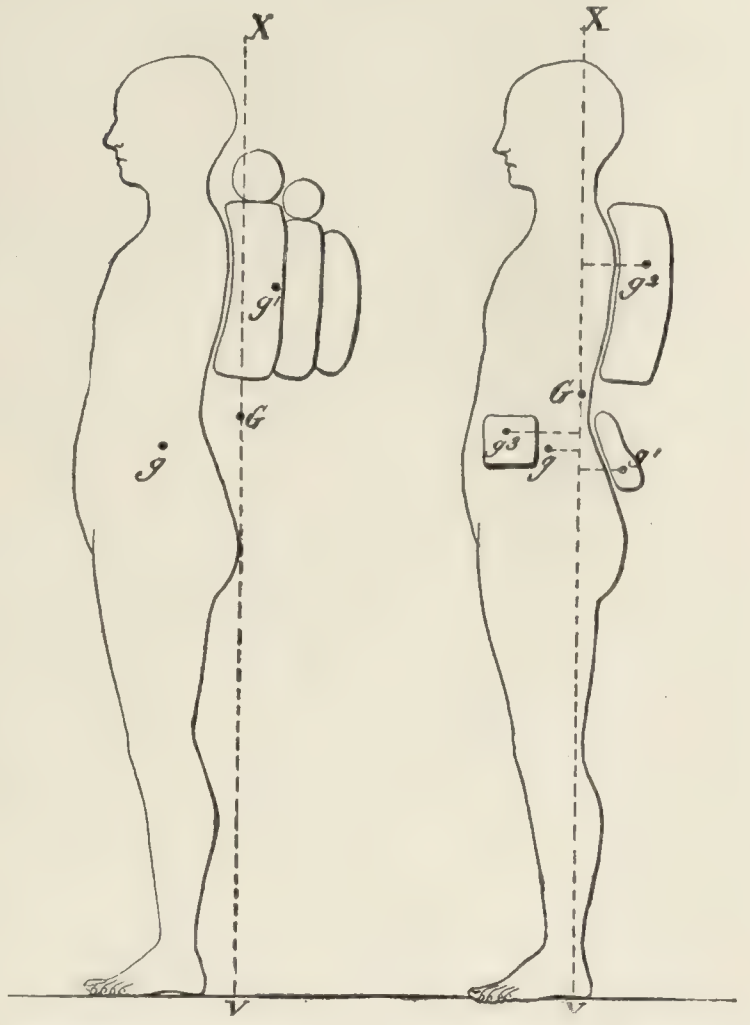


FIG. 117.—Improper and Proper Method of Disposing the Equipment. (After Laveran.)

Aitken states that "next to the continuous inspiration of bad air the imperfect or continuously obstructed expansion of the chest (by the equipment) does most to bring about diseases of the heart and lungs." Viry observed deformity of the thorax following the constant carriage of heavy equipment by immature young men; while Woodhull states that with such youths even the straps of the canteen and haversack may press upon them to their disadvantage. The frequency of the pulse is naturally much greater in men who execute military exercise with the full equipment than in those who execute the same movement without these burdens. Parkes noted that the average rate of 124 resulting from a march of five hundred yards without the knapsack was increased to 148 over the same course with the knapsack, while respirations were proportionately accelerated.

The weights should be so disposed that, when carried, they fall as near as possible to the center of gravity. This, in the upright position, is between the pelvis and the center of the body, usually between the umbilicus and the pubis—a vertical line prolonged to the ground passing through the astragalus just in front of the os calcis. This point naturally alters with each change of position, while if weights are carried away from this vertical line the center of gravity is entirely displaced. Hence the centers of gravity of the burden and of the body should coincide as closely as possible. The greatre the distance of the load from this point the greater its leverage and apparent weight; and thus a lighter article of equipment, some distance from the center of gravity, will serve to balance a much heavier weight placed opposite but closer to the line passing perpendicular-

ly through this center. It is of the greatest practical importance that the equipment should be so disposed and balanced that the bodily equilibrium is naturally maintained without the unnecessary expenditure of muscular energy—for constant effort at balancing rapidly induces fatigue. The burden is also more readily borne as its points of support are increased, and the weight should be distributed as much as possible over the person so as to avoid the excessive fatiguing of one group of muscles. The back, shoulders and pelvic brim must bear the brunt of the strain, and straps from the shoulders and waist distribute the weight more advantageously. The lumbar straps seen in the British equipment and the Novior and Merriam packs support a large proportion of the burden. The practice of suspending nearly the entire equipment from the shoulders, as is done with the blanket-bag used in our service, possesses many serious defects. Weight carried on the pelvic structures is borne in the strongest part of the body and will be carried with less distress than if suspended from the shoulders. Further, the soldier who slightly loses his equilibrium requires the expenditure of less effort for its recovery if the weight is closer to the ground, and the leverage shorter, than when the weight is placed further above the center of gravity of the body—and the march is a constant alteration in equilibrium. Per contra, the burden must not be so low as to interfere mechanically with locomotion or constrict the muscles which are concerned in marching. The weight must in no case compress on the lungs, or in any way interfere with respiratory movements or the elimination of carbonic acid, or hinder the transmission of blood through the lungs, or render difficult the action of the heart. It is self-evident that the distribution of the burden carried by the soldier should be such that no large nerves, blood-vessels or important muscles are pressed upon. It is equally important that the leverage pressure resulting from placing a weight outside the line of support, with the corresponding constriction of straps which hold it there, must be reduced to the minimum and distributed to points where it will do least harm. As far as possible the space of actual contact of the burden with the body of the carrier must be also reduced, in order that he may not become overheated in the midst of his exertions. The carriage of an undue amount of weight suspended from the belt is inconvenient and injurious, the resulting compression of the abdominal walls and viscera being highly undesirable.

Carrying Apparatus.—In addition to the requirements already enumerated, the pack or knapsack should be simple in design, as well as light, durable and water-proof. It should be easily put on and easily removed, so as to leave the soldier but the ammunition, water and ration. It goes without saying that free use of the hands and arms in manipulating the weapon or in overcoming obstacles is essential, and that all belts and apparatus necessary for the carriage of the equipment should be as light and comfortable as possible.

In our own service the method of carrying the equipment is certainly in a transitionary and highly unsatisfactory state. Formerly the spare clothing and small articles were carried in a heavy and generally objectionable knapsack, but during the Civil War "at the opening of the spring campaigns our soldiers, heavily weighted with the old-fashioned knapsacks and the accumulation of the winter, after the first few miles, exhausted

by their packs, availed themselves of a favorable opportunity to stop by the roadside and to take from their knapsacks a few things, which they rolled in their blankets, the ends of which they tied together and slung over their shoulders, abandoning all other articles of clothing." Such an extemporized arrangement did not so much imply approval of the blanket roll, which thus came into existence, as condemnation of the carrying apparatus furnished at that time. Had the troops been provided with an easy fitting, light and comfortable knapsack, and had they in the first place been prevented from overloading themselves with the many useless articles always found in the kit of the volunteer recruit, it may be doubted whether the blanket-roll would ever have made its appearance. In 1878 a general equipment board commented as follows: "The blanket-roll, during our wars, has superseded all knapsacks and is strongly advocated by officers of high rank and great experience, but it is believed by the board that the blanket-roll is in favor among soldiers, not so much because it is the best way of carrying the kit, as because all other devices thus far adopted or tried have been comparatively so inferior." Such opinion, expressed twenty years before, was also applicable during the Spanish-American war, when the carriage of the equipment in this manner was almost wholly the rule among our troops.

The blanket-roll is excellent for light marching order, but if, in addition to the shelter tent, the overcoat and poncho are also included in the roll, the latter becomes both heavy and cumbersome. Under such circumstances the poncho might be omitted if the blanket and overcoat were water-proofed, and the latter could perhaps be rolled and carried separately above the sacrum by a strap arrangement similar to that used in the British service. As compared with the blanket-bag the roll is much superior, has the advantage of not so greatly impeding respiration and circulation, and is hence carried with much less discomfort and fatigue. Even though comparatively superior to the blanket-bag, the roll is, however, possessed of several positive defects. The kit carried in this manner is somewhat insecure, and in warm weather the enveloping blanket-roll does much to overheat the soldier. The breast is to a certain degree oppressed, the clothing held against the person and the ready manipulation of the piece impaired. These disadvantages are very marked when the full equipment is carried in the roll.

An improvement over the simple roll consists in the use of a canvas clothing case four and one-half feet long, eight inches wide and having a weight of about eight ounces. This is divided for the sake of convenience into three compartments by transverse stitching, will contain the ordinary kit of the soldier and is itself carried in the rolled blanket. It has a special value in preventing the soiling or dispersion of the articles of the equipment after camp has been established, and the shelter tent and blanket have been removed to furnish protection against storm and cold.

The blanket-bag officially prescribed for use in our military service is possessed of few good qualities and many grave defects. Intended for use in campaign, it is uniformly left behind by troops taking the field—the blanket-roll being preferably employed—and hence fails absolutely of fulfilling the sole purpose for which it is provided. The blanket-bag is heavy, cumbersome and illy designed. Receiving its entire support from the

shoulders, together with the haversack and canteen, it aids greatly in placing the entire weight of the equipment, except the ammunition, on a limited space much above the center of gravity. The bag itself is unnecessarily broad, and the increased leverage so provided for its contents results in a powerful tendency toward pulling the soldier backward, requiring a constant and highly undesirable expenditure of muscular force, and the assumption of a constrained position, in the maintenance of equilibrium. In arranging the present equipment there appears to have been no attempt, through the disposition of weights anteriorly, to compensate for the heavy burden carried behind. Canteen and haversack are slung from the shoulders, their cross straps doing much to embarrass the soldier on the march, and are naturally pushed to the rear to facilitate locomotion. The cartridge belt, the solitary article of the present equipment not suspended from the shoulders, and the only one receiving support close to the center of gravity, is unfortunately heaviest in the rear and lightest in front, where a broad buckle takes the place of the more weighty cartridges. Hence, if the soldier be divided laterally by an imaginary vertical plane, it is found that the following weights are disposed over the posterior half of the body:

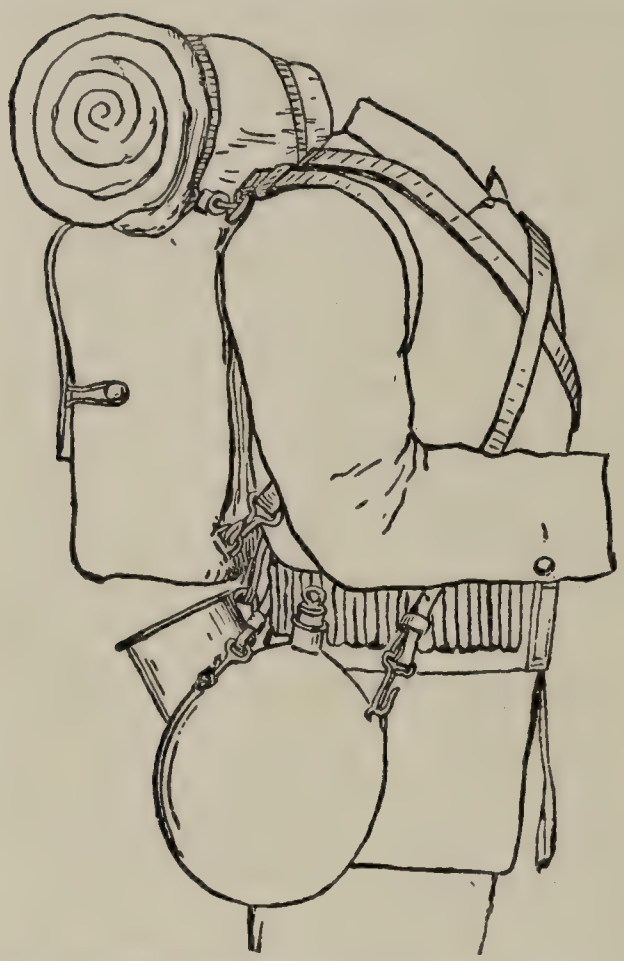


FIG. 118.—Blanket-bag and Equipment Used in the United States Army.

Blanket bag, packed	29 pounds.
Cartridges and belt (portion)	4 "
Canteen, full	2¾ "
Haversack and mess kit	2¾ "
Ration, one day	2 "
Total	40½ "

To offset this heavy weight no provision is made save in the portion of the cartridge belt and smaller fraction of the cartridge supply, weighing in all not more than three pounds, lying in front of the bisecting plane. Bearing these facts in mind, it is not strange that troops evade carrying the blanket-bag whenever possible, throw it away if hard pressed, and, when compelled to carry it, stagger in at the conclusion of the march in a condition of exhaustion and with the body inclined forward at an angle of 30° or 35°. The painful constriction of the axillary vessels and nerves by the encircling straps of the blanket-bag is often sufficient to produce numbness and swelling of the upper extremities, while the constant tension on the squared shoulders greatly impedes the costal respiratory movements, especially when the soldier is fatigued. Lying, as it does, close to the person, it overheats the back during the march and predisposes to chilling after its

removal. At the same time, not being sufficiently restrained at the bottom, every step causes it to swing after the manner of a pendulum; each stride being accompanied by a blow over the lumbar spine which, always disagreeable, becomes most distressing and painful during a long march.

It is safe to say that the present blanket-bag is the most vicious article of the equipment of the United States soldier. Its use, even for short marches, is responsible for much discomfort, and its absolute worthlessness for field service is practically demonstrated beyond the possibility of discussion by the fact that it is never willingly used by troops in campaign. It cannot be too quickly discarded officially in favor of a modified blanket roll, or, better, some such more rational apparatus as the valise of the British foot service, the Merriam pack or the Novior knapsack.

For the pack devised by General Merriam the following claims, which appear to have been substantiated by ample experience, have been advanced by the inventor:

"First. It places a large proportion of the weight of the soldier's pack directly upon the strong bones of the hips, relieving the shoulders and spinal column from strain.

"Second. The stiff side braces stand in the direct line of the shock produced by the act of marching, viz., that of the advanced leg as it comes to the ground; hence they receive the shock and transfer it to the strong base of support above named.

"Third. It prevents all pressure upon the shoulder blades, leaving the shoulders and arms entirely free for action, and allows free ventilation of the back—the pack not even touching it necessarily.

"Fourth. The shoulder straps, by their form and vertical attachment, no longer press upon the nerves and vessels of the armpits, consequently preventing numbness and swelling of the hands.

"Fifth. The invention avoids every form of cross belt, leaving the chest entirely free from constriction, so that the coat and even the waist belt may be thrown open on a hot march without deranging the equipment.

"Sixth. It distributes the weight and shock of the pack, and removes leverage and constriction from the vital parts of the body to such an extent that the pack is now arranged to contain rations, as well as clothing, extra cartridges, etc.; thus dispensing with the cumbersome and unsightly haversack, heretofore carried under the arm by a cross belt, and tolerated only from necessity.



FIG. 119.—Merriam Pack.

"Seventh. The side braces are interchangeable, and are easily detached from the pack and joined together, forming an excellent pole for the shelter tent.

"Eighth. The equipment is adjustable to all sizes and forms of men, and is light, simple and serviceable in all its parts.

"Ninth. It sustains the cartridge box, or belt, in exact position, whether full or empty, thus avoiding the necessity for wearing the waist-belt tight and uncomfortable.

"Tenth. In case of an accident to the side braces which cannot be met at once by their interchangeability, the equipment is instantly convertible, so as to be carried temporarily upon the shoulders.

"Eleventh. This single equipment is adapted to the lightest as well as the heaviest marching order."

While the blanket bag constantly presses on one place, this pack can be adjusted so as to bring the weight either on the hips or shoulders as desired. This change can be made while marching. The freedom of the body is not impaired by this apparatus, nor is there any galling of the back, shoulders and axillæ through pressure—so common with the regulation equipment. Its use permits an erect carriage not possible where the blanket bag is worn. The weight, of course, varies with the articles carried, but is only slightly greater with the same equipment than when the blanket-roll is employed.

This pack has been thoroughly tested in the Seventh United States Infantry for the past six years and has recently been issued to other regiments for trial, while it has been adopted by the National Guard of New York, New Jersey and other states. In Europe, the general principle upon which this pack is based has been adopted in the armies of France and Austria. Wherever used it appears to have given satisfaction—as an apparatus constructed on rational principles will naturally do.

That this, or a similar method for carrying the equipment, has not been generally adopted in our service, appears to be due rather to the attitude of the Ordnance Department than to that of such line officers as have had opportunity for practical comparison between the blanket-bag and this apparatus. A theoretical objection which has been urged is that this pack is so intricate that its usefulness is largely impaired. The regiment above named, however, was probably the only one which carried the equipment in the expedition against Santiago in any other manner than the blanket-roll, a fact that speaks volumes in the favor of this apparatus as compared with both the blanket-bag and roll.

To the suggestion that this pack be made in divisible form, as is done in France and Austria, General Merriam replies as follows: "We can make a divisible pack if desired, of course, but it will cost more and necessarily weigh more, while having perhaps one doubtful advantage, viz., that a part of the pack can be removed to wagons, when possible, in a body. It has seemed to me that my pack, when properly comprehended, provides for all this better than the divisible pack. When the divisible pack is divided the center of gravity is greatly changed of course, as the remainder of the pack retains its old position. My plan avoids the disturbing of the balance, or center of gravity, by removing articles not required for immediate use, whether from the interior of the pack or from the exterior, and thus leaving the remainder with center of gravity unchanged." If necessary to divide the kit, "which would seldom be exactly the same, as circumstances would constantly vary, I propose that each soldier be furnished

for campaign with a small muslin sack, about as large as a pillow case, to be marked with his company, regiment and number. This he could fold up in his pack ordinarily and have it always ready to receive any articles which could be spared from the pack proper, as indicated to meet the emergencies of campaign. These sacks would cost perhaps five cents, and weigh six ounces empty, yet they would serve to cover and identify the soldier's kit to be spared temporarily. By this method the soldier can always be relieved from carrying on his back such articles as he must have for a campaign, and yet does not need for use during the constantly recurring short periods of separation from supply trains."

The Novior apparatus, recently designed on the general principles shown in the Merriam pack, is now being practically tested in the Belgian army. The knapsack portion is made of water-proof cotton duck, stretched on a wicker frame, the weight of the entire apparatus being said to be only about two and one-half pounds. This apparatus is constructed on rational principles and appears to avoid the several minor disadvantages presented by the Merriam equipment. At present, with a few slight changes to better suit the special needs of our service, it would probably be the best apparatus for carrying the equipment which could be adopted for use in the military establishment of the United States.

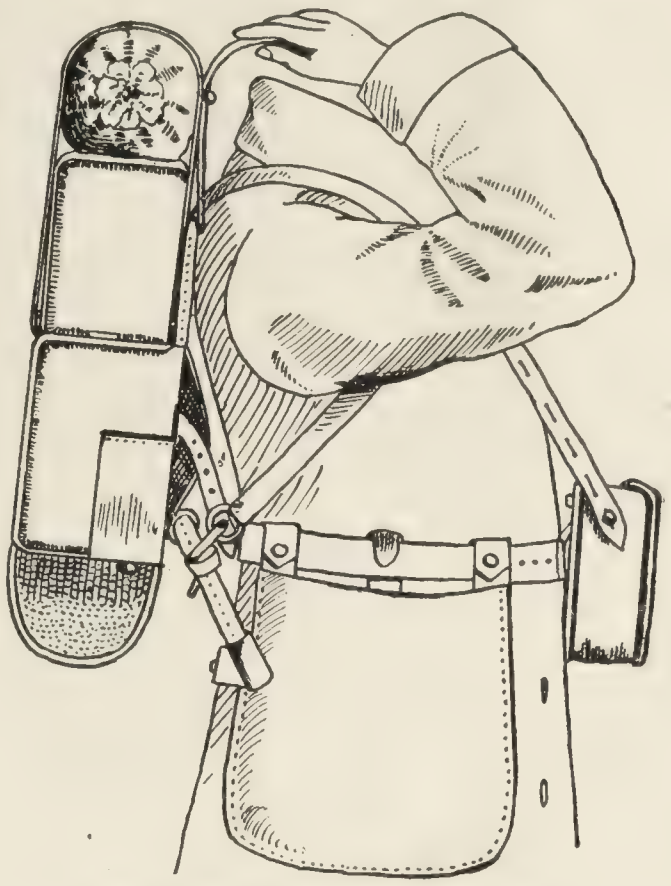


FIG. 120.—The Novior Knapsack.

Among foreign nations the best arrangement for the carriage of the equipment has been claimed to be that of the British service, in which the shoulders and sacrum are used as points of support. As stated by Notter and Firth, the pack is suspended at the level of the loins by two shoulder straps fastened to the waist belt in front. It is very light and simple, the movements of the arms, shoulders, and chest are remarkably free, while the pack can be readily detached from the rest of the equipment by merely unbuckling the belt. According to other observers, however, it would seem that this apparatus still leaves much to be desired; its defects being clearly pointed out in the report on mobilization of the First Army Corps, in 1896, as follows:

"(1) When packed, the valise is convex at the back and is therefore constantly wobbling.

"(2) Without ball ammunition it is badly balanced.

"(3) Practically the whole strain comes on the braces, which cut into the shoulders and check lung expansion.

"(4) The weight is so distributed that the heaviest portion, *i.e.*, the great-coat, is carried on the waist and drags on the loins.

"(5) Equipment cannot be taken off and put on quickly without assistance."

On a short man all these drawbacks are emphasized. The lower the valise equipment hangs the more it drags; and yet if raised much above the man's shoulders it prevents the circulation of air about the neck. Again, any thickening of the valise by putting the great-coat either inside or outside the flap is to be deprecated, having in view the increased strain on the shoulders caused by leverage. The English valise is made of japanned canvas. The mess tin may be carried on or under the overcoat or may be attached to the waist belt. The cartridges are located in front to offset, as far as possible, the weight behind.



FIG. 121. — British Infantryman, Showing Method of Carrying the Equipment. (After Laveran.)

The Austrian kit is carried in a leather knapsack strapped in the overcoat, to which a camp kettle is fastened. The whole is at once detached from the person by drawing a pin in the right shoulder strap.

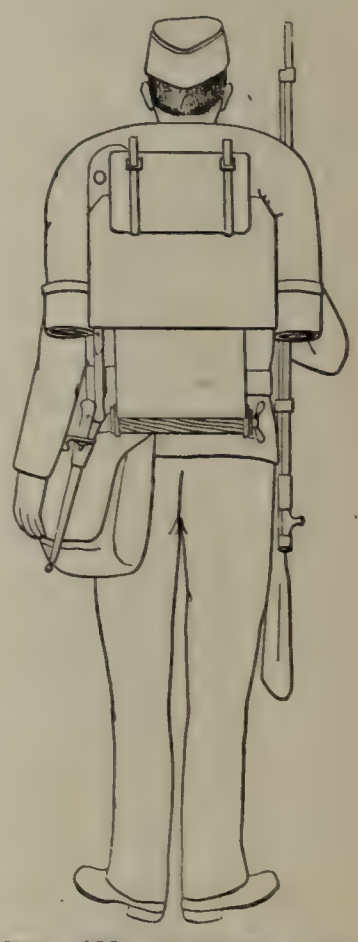


FIG. 122.—Disposition of Equipment in the Austrian Army.

The arrangement of the Russian equipment is in general similar to the blanket-roll used by our own troops. A large canvas bag is suspended from each shoulder; the one on the right containing small articles and the one on the left the ration. The overcoat is rolled in the shelter-tent and



FIG. 123.—Russian Infantryman, Fully Equipped.

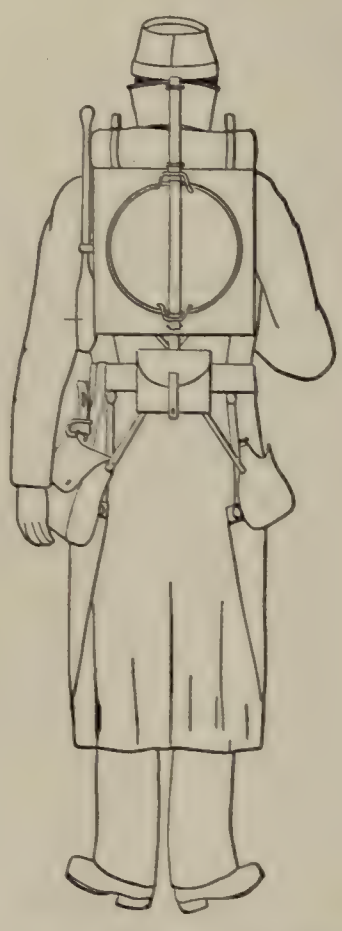


FIG. 124.—French Infantryman. (After Laveran.)

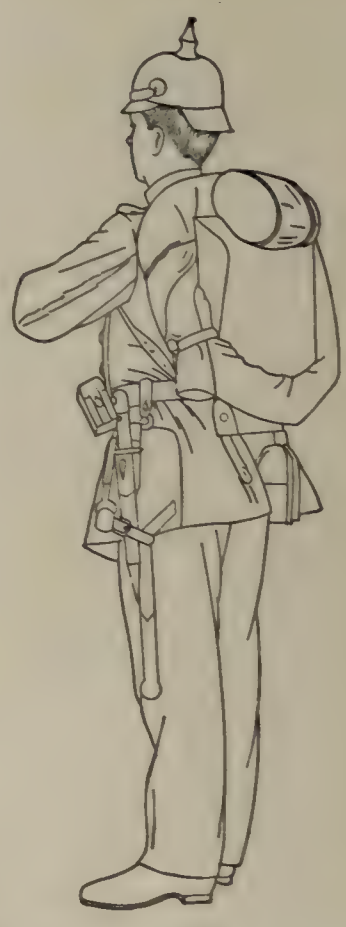


FIG. 125.—German Infantryman. (After Viry.)

slung over the left shoulder, a case containing the extra pair of boots being attached to the clothing roll.

The French soldier carries a leather knapsack upon which the blanket is strapped; and the carriage of the equipment in the Italian service is similar. In the German army the kit is carried in a leather knapsack strapped to the overcoat, the camp kettle being attached to the latter. The haversack, to which a drinking-cup is attached by a clip, is worn on the right side, the entrenching tool and bayonet being carried on the left hip.

Under any circumstances, whatever be the weight carried or the method or apparatus employed, the more ready transportation of the equipment is to be accomplished by the soldier only as the result of long experience and careful training.

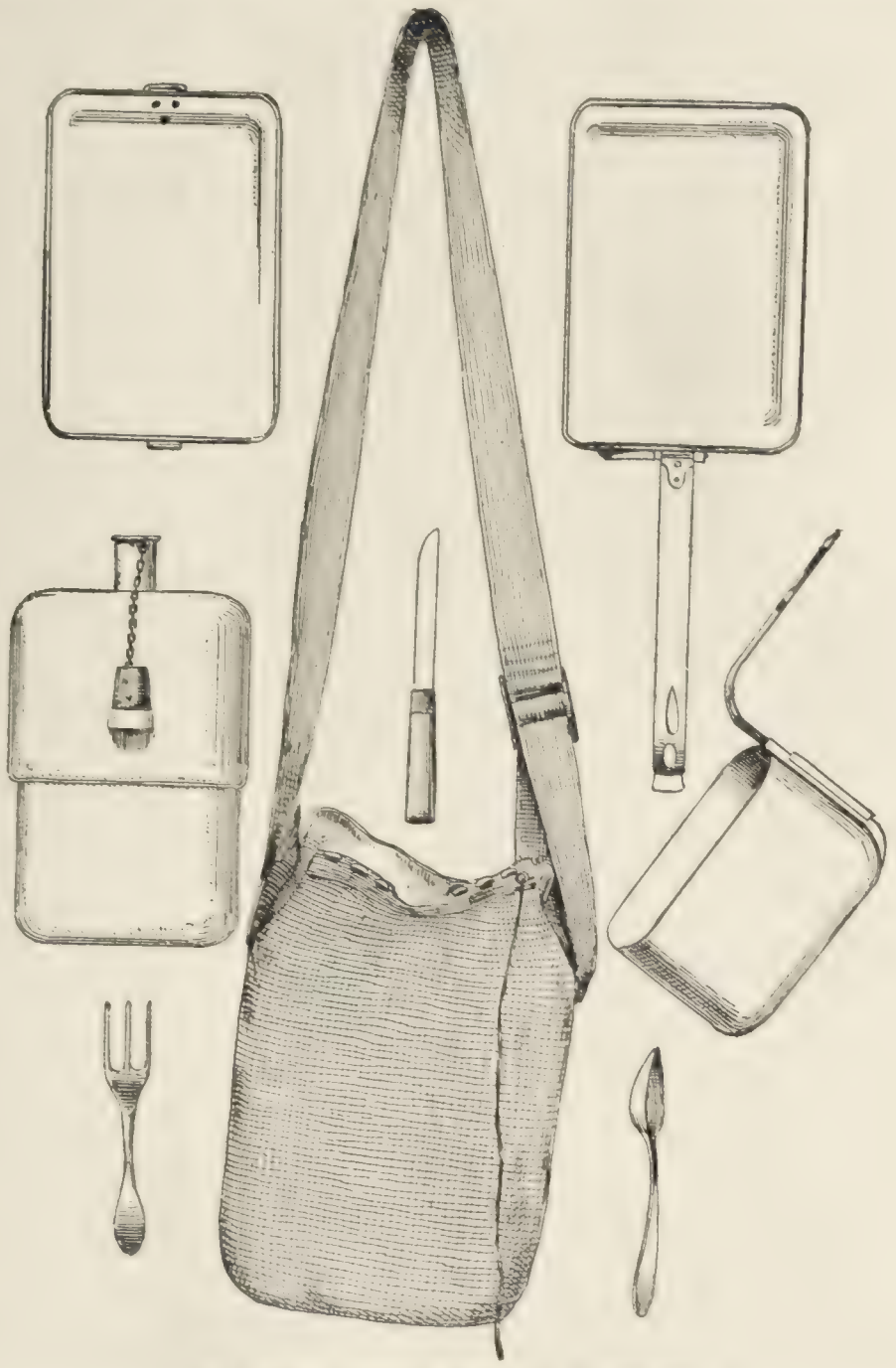


FIG. 126.—Preston Mess-kit, Unpacked.

THE MESS OUTFIT.

Under this heading may be conveniently grouped the meat can, tin cup, knife, fork and spoon, together with the canteen. The first-named utensil is of stamped metal and made on a pattern shown by experience to be best suited to the preparation and preservation of the field ration. It is composed of two shallow oval dishes held in apposition by a folding handle, the space between them serving during the march as a receptacle for the meat ration. It appears to be satisfactory in all respects save that of weight, the latter at present being needlessly great through the persistent use of heavy metal—and the same remarks apply also to the tin cup. The knife and fork supplied are excellent, but the spoon may advantageously be made of lighter material. The canteen is well proportioned and of sufficient size for all but tropical service, but for the sake of the greater coolness of its contents a layer of heavy felt should be placed under the present covering of white cotton duck. It is a question whether the addition of a small orifice at the top for the admission of air, capable of being tightly corked, would not be justified by the increased convenience afforded while drinking.

The Preston mess outfit is an ingenious combination by which the mess tins, cup, knife, fork and spoon are all nested around the canteen, inside a felt-lined canvas cover suspended from a strap of webbing. The utensils are made of aluminum, and when placed together are very compact and portable. The complete outfit, with empty canteen, weighs just one pound, or two pounds less than the same articles of the present outfit. As mentioned elsewhere, in an ordinary march of twenty miles this represents a saving in energy equal to that required for the transportation of practically the entire equipment of the soldier through one mile. The advantage in decreased weight is positive; the disadvantages which may be urged against this special form of outfit are:

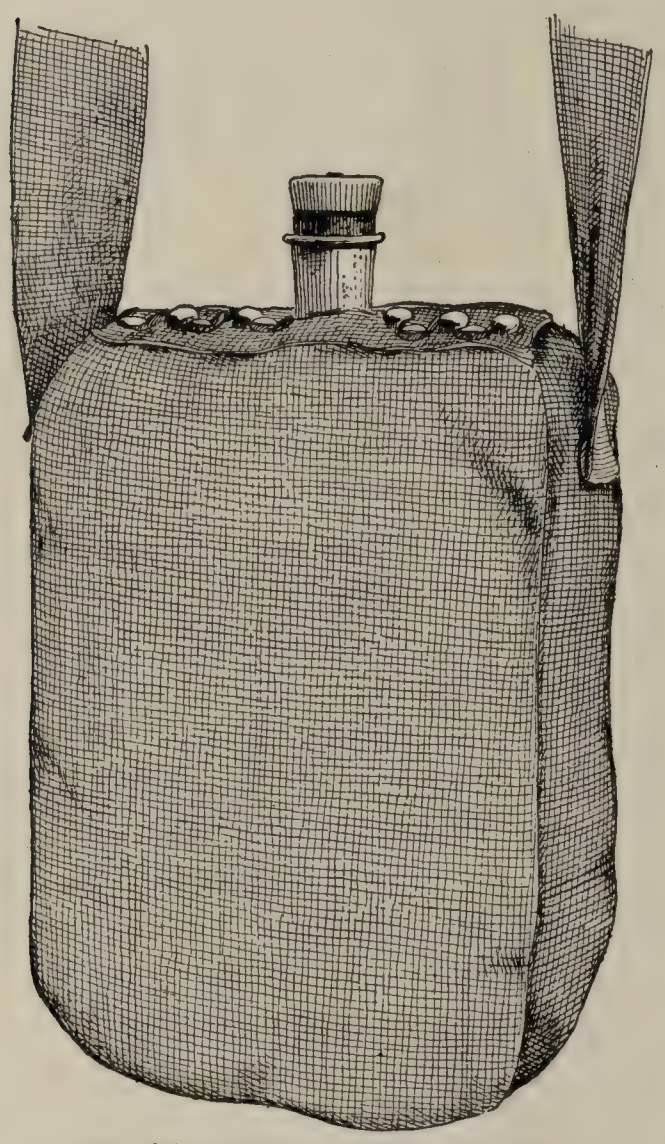


FIG. 127.—Preston Mess-kit, Packed.

(1) That the metal is too soft and bends readily.

(2) That the entire outfit has to be unpacked to get at the cup, in case it is desired to take advantage of a water supply on the march.

(3) That the cup is too narrow on the bottom, and is insecure when placed on the fire for cooking purposes.

(4) That the end of the cup is too sharp and hurts the lips while drinking.

(5) That the special metal used, being an extremely good conductor of heat, is liable to induce burns of the lips.

From the standpoint of hygiene these defects, though real, do not counterbalance the great advantages of diminution of weight and increased portability.

Whatever be the special pattern in which the mess ontfit is to be supplied, on account of the combined lightness and strength of aluminum its several articles, save the knife and fork, should preferably be made of this metal. The cost of aluminum is no longer a bar to its employment, and the retention of the present material requires the carriage of a wholly unnecessary weight on the part of the soldier. In the French, German, Belgian and other armies this metal has been adopted for the manufacture of canteens and cooking utensils—as well as cap ornaments, buckles, shoe nails and such other metallic portions of the equipment as could be made of this material—after exhaustive trials in which its superior merits for such purposes have been amply demonstrated.

Aluminum is strong, resists oxidation better than iron, is easily cleaned and is remarkable for its lightness; its density being 2.56 where that of iron is 7.7 and that of copper is 8.78. Its melting-point is 700° C., and hence it is not readily fused. According to Plagge, aluminum is such a good conductor of heat that cooking is more readily accomplished with it

than with iron utensils. The same observer found that distilled water did not affect aluminum, but boiling with water containing a large proportion of iron gave a slight deposit of sulphate of iron on the metal. The latter was also attacked by vinegar in the strength of four to six per cent. of acetic acid; alloys of aluminum with tin or antimony being more readily corroded than the pure metal. Longuet noted that food cooked in aluminum utensils was entirely free from metallic taste. After long standing in the presence of coffee he found a slight precipitation of tannate of aluminum; and with hard water, after a long time, of minute insoluble masses of silicate of aluminum. Such small amounts of alum have, however, no toxic significance. This metal is very bright and hence should be blackened externally when used for military purposes, as is done in the German army.

Aluminum has not been adopted in our service through the apprehension of the Ordnance Department that it would not prove to be of sufficient durability, but in the light of the ample experience of other countries this objection would not seem to be well founded. The official report made by Balland to the French Minister of War on the use of aluminum utensils in the recent Madagascar campaign was entirely favorable to their use, the report concluding with the statement that this metal is "durable, and little influenced by fire, fluids or solids." Articles made of the alloys of aluminum appear to be more satisfactory for military use than those made of the pure metal, being stiffer and much less liable to injury.

CHAPTER VII.

CAMP SITES AND CAMPS.

I.

CAMP SITES.

SANITARY preference, in the selection of the camp site, must often yield to military necessity; but the extent to which the former may be disregarded is only to be measured by the exigencies of the military situation. When in the face of the enemy and the camp is but for a single night, military reasons may justifiably prevail—a possible future diminution of efficiency being accepted as the price of present position—but under other conditions sanitary requirements should, as far as possible, govern. At all times, however, even in conditions of peace, certain limitations as to selection are necessarily imposed. Troops en route must always encamp near the line of march, irrespective of topographical conditions, and the proximity to a suitable water supply often determines the site. Nevertheless, under all conditions, however unfavorable they may be, there is always a certain latitude of choice and a best disposition which can be made.

The proper location of the camp, as a matter of the greatest importance in maintaining the health and efficiency of troops, demands intelligent and careful consideration. The site should always be selected as if for continued occupancy; since it may frequently happen, particularly during campaign, that the intended bivouac becomes, through necessity, a camp of semi-permanent character. Hence it should be remembered that there are many places which at certain seasons of the year may be safely occupied for a short period, where to encamp at other times would invite disaster. The camping ground should be chosen with a view to the convenience of the command, should permit of ready internal communication, and should be located, if at all of a permanent character, near a road practicable for wheeled vehicles. Possible meteorological conditions should always be taken into consideration, and the locality should never be such as could receive the overflow of a water-course or the surface drainage from high ground during rain-storms.

The desiderata in the selection of the camp site, from the standpoint of the line officer, are wood, water and grass; in abundance and of good quality. To these the sanitary officer will add dryness of soil and surroundings, elevation of site and protection from winds.

No sanitary precautions can fully atone for the selection of an unhealthful camp site, even though they will do much toward the diminution of sickness, and hence the prompt re-establishment of a badly located camp in a more desirable locality is imperative. On the other hand, the best of natural sites will quickly be rendered unhealthful by inefficient

police and disregard of soil contamination—but with the observance of proper sanitary regulations and a careful police an originally good camping ground will continue to be healthful for a proportionately longer time.

An abandoned camp site should never be utilized by another command, for the slightly greater labor involved in the clearing or arrangement of a new camp area is more than counterbalanced by the increased safety of the troops. Old camp-grounds may be considered as permeated with the organic soakage incident to human occupation; soil contamination is certain, and there is a strong probability of its specific infection. In the rare cases where military necessity requires the occupancy of ground in the vicinity of old sinks, the latter may be dug out and the contents removed —five or six feet of the surrounding earth being also taken away—disinfection by lime practiced, and the pit filled with fresh earth. Such sites, however, are used in defiance of the laws of hygiene and obviously should always be avoided.

Topography.—While many factors combine to determine the healthfulness of localities, there are certain physical features of the surface of the earth which, as shown by experience, may be accepted as fair indications of the salubrity of the location in which they occur. Every region has its character impressed upon its surface contours, and the significance of these the sanitary officer should be able to interpret at a glance. Wide and flat areas will, as a rule, indicate a soft subsoil, while a steep gradient implies the presence of an underlying stratum of some hard material, such as gravel. Rock will usually be apparent through its outcroppings; but, in general, the slope of a subjacent impermeable layer will approximate that of the surface itself. The amount of soil moisture may be excellently estimated from the character of existing vegetation; in many cases even the height of the ground water may be determined by reference to the level of some neighboring lake or river.

High ground should always be selected for the camp site; since not only is the surface drainage better but exposure to air currents, as well as lessened atmospheric pressure, increases the rapidity of evaporation. Elevated table lands are always salubrious. Situations at the base of hills are usually unhealthful, since the ground water, coming from a higher elevation, is checked in its flow by the sudden change of grade and forced to the surface—but such a site may be acceptable if a deep, transverse ravine completely intercepts drainage from the high ground behind it.

Camps should never be located in ravines or the dry beds of water-courses. Air currents follow the trend of ravines—the movement being upward during the heat of the day and downward at night—and it is not desirable that the camp site should be constantly traversed by such breezes; while in a mountainous country a sudden heavy fall of rain will often quickly convert the dry bed of a ravine into a rushing torrent. Low plains, surrounded by high land, are proverbially unhealthful; and ground which is perfectly flat or slightly concave is not suitable for camp purposes on account of the difficulty of accomplishing drainage. In such localities the accumulated storm water can only be removed by evaporation or soakage, and a moderately rolling surface best fulfills the requirements of drainage. Narrow, circumscribed valleys and punch-bowl depressions are, during warm weather, excessively hot during the night as well as by day. Ex-

posed ridges should be avoided in cool weather since they are constantly swept by cold winds, but for that very reason they afford an excellent location for summer encampments.

An abundance of water is of the first importance for troops, and encampment in its vicinity is a necessity for a marching command, irrespective of the nature of the camp site and a possible exposure to malarial infection. Still, proximity to bodies of water does not necessarily render a locality unhealthful, and the bank of a lake or river, if not marshy, may make an excellent camp site. The vicinity of marshes, rice fields, irrigated lands or areas periodically overflowed and bared is always dangerous to health and favorable to malarial infection, particularly so in the last instance. While malarial diseases may be regarded as the certain accompaniment of a fluctuating water-level, they as certainly greatly decrease if the water level be made unvarying. Fresh-water marshes at any altitude should be avoided, if only for a single night; but the vicinity of salt marshes is, as a rule, healthful. Should the location of a camp near a marsh be rendered necessary, a hill, rising ground or screen of heavy timber should, if possible, intervene. Localities at the mouths of rivers are usually unhealthful, and alluvial deposits or bottom lands should always be avoided; possessing a high ground water and a large proportion of organic detritus, they are not to be selected for military camps. A location to which surface or subsoil waters gravitate is always undesirable, and sufficient inclination readily to remove surface waters is of the greatest importance. In the encampment of large commands, wet places in the camp area should be avoided as much as possible. This may be accomplished by slightly altering the line of the encampment or by throwing organizations back *en echelon*. As a general rule, the immediate vicinity of the camp should always be as dry as the soil of the site itself.

Newly ploughed ground should never be employed for camping purposes, although a site which has been long under cultivation is usually healthful. All soil upon which the covering of turf has been destroyed is dusty in dry weather; the degree depending upon the nature of the soil itself. Dust is an excellent vehicle for the dissemination of micro-organisms, and undoubtedly plays an important part in the distribution of zymotic disease, particularly typhoid fever, in military camps. It is directly productive of bronchial and conjunctival irritation, contributes largely to the discomfort and annoyance of troops in camp, and directly impairs discipline and efficiency through the indifference to personal cleanliness which it engenders.

Soil.—A porous soil with a deep bed-rock makes the best of camp sites. Deep gravel and sand are always healthful; but the latter is soon fouled with organic refuse and hence becomes unsafe for camping purposes A sandy soil with a high ground water or closely lying substratum of clay should always be avoided, as should also such sands as contain a considerable proportion of organic matter. The subsoil of the camping ground, as well as the surface, should always consist of sand, gravel, or similarly pervious material.

The most unhealthful site for a camp is on a clay soil, or where clay subsoil approaches the surface. As expressed by Owen, ridges of clay are cold and every depression is a marsh. Chalk, if free from clay, is health-

ful; but chalk marl is impermeable, cold, damp and insalubrious. Alluvial soils often consist of thin strata of sand alternating with those of clay, both being mixed with a large proportion of organic matter. They contain much moisture, and thus render the overlying air constantly damp through evaporation. Limestone regions are usually salubrious, but marshes are of somewhat frequent occurrence through the retention of water in pockets and cavities. Magnesian limestone should be avoided. Sandstone is usually healthful; but if its formation is a thin layer placed over an impermeable stratum it is unhealthful. Granite, slate, trap and metamorphic rocks, if the slope of the surface is sufficiently great to enable storm water to run off rapidly, make salubrious camp sites. If, however, they contain cracks or depressions, storm water collects and stagnates and malarial conditions often result. Retentive strata are those of clay and hard rock; porous layers are those of gravel, sand stone and chalk. An impermeable layer, if present, should be at such a depth as not to influence the moisture of the surface soil, through evaporation of the upheld ground water or by capillarity. If the camp must be pitched upon an impermeable soil, the locality affording the best surface drainage should be chosen.

Soil Moisture and Ground Water.—From a hygienic standpoint the power of soils to absorb and retain moisture constitutes one of their most important properties. Excessive moisture of the earth is a cause of fogs and atmospheric dampness; while the evaporation of such moisture renders the surface cold and chilling, and largely favors the sudden local changes of temperature by which the health of troops in camp is often unfavorably influenced. Exhalations from damp ground are powerfully depressing to the vitality of the human organism, and favor the occurrence of rheumatism and neuralgia as well as the invasion of the system by infectious germs, certain of which best retain their vitality and perpetuate their kind amid such environment. Diseases of the respiratory tract are not only more prevalent but more fatal on moist than on dry soils, possibly because the slight congestions and catarrhs which are produced by dampness may so modify the mucous membrane as to render lodgment and development by the specific micro-organisms less difficult of accomplishment.

Soil moisture is largely derived from the rainfall, but the more severe the rain the less liable is the water to penetrate the ground. In amount, it necessarily depends upon the supply and upon the power of the soil to absorb and retain it—permeable and absorbent soils being, in this respect, quite different. Soil moisture is also influenced by surface configuration, the nature of the soil, the amount of organic matter present, evaporation, absorption of atmospheric moisture at night, fluctuation in the level of the ground water and by capillarity. Daubree estimated that water is raised by capillary attraction to the height of one foot in the case of sands, two feet in chalk and five feet in clay; a high ground water thus readily rendering the surface above it both damp and cold. The impermeability of certain soils to rain is relative rather than absolute—5 to 10 per cent. of a rainfall readily penetrating the so-called impervious strata of rock and clay. Stiff clay may take up and retain about 20 per cent. of water by weight—or three times as much as is, in practice, retained by sand. Gran-

ite and marbles absorb 0.4 to 4 per cent. by weight. In general, the amount of soil moisture appears to vary directly with the depth below the surface and the amount of contained organic matter. The absorbent power of various kinds of soil, as regards atmospheric moisture, has been determined by Schuebler, who found that 500 centigrams of earth, spread over surfaces of equal area and exposed to the same atmospheric conditions, absorbed moisture as follows:

Kind of earth.	In twelve hours. Centigrams.	In twenty-four hours. Centigrams.	In forty-eight hours. Centigrams.
Silicious sand	0.0	0.0	0.0
Calcareous sand	1.0	1.5	1.5
Gypsum	0.5	0.5	0.5
Light clay	10.5	13.0	14.0
Heavy clay	12.5	15.0	17.0
Argillaceous earth	15.0	18.0	20.0
Pure clay	18.5	21.0	24.0
Calcareous matter, finely powdered	13.0	15.5	17.5
Humus	40.0	48.5	55.0

Evaporation of moisture occurs from soils as it does from the surface of water; its rapidity varying according to the nature of the ground, and a silicious sand losing its moisture nearly three times as quickly as a clay soil. All soils diminish in bulk on drying. Clay cracks—a property of great service in drying cold, retentive localities. Altitude does not necessarily affect soil moisture if the site be commanded by elevations of still greater height, except as evaporation is thus favored. To determine the amount of soil moisture a boring is weighed, thoroughly dried at 110° C., and the weight again determined.

Soil moisture and ground water are two entirely different conditions, the latter forming a solid sheet of water except so far as it is separated by particles of soil. Ground water lies at a variable distance from the surface and is in constant movement; whence it happens that with a porous soil infectious material may be transported by it through some distance. The water-level is subject to constant fluctuation; this being of no importance if slight, but rendering the camp site particularly unhealthful if frequent and extensive. The level of the ground water should never approach nearer than eight feet to the surface of a proposed camp site, and should preferably be several times that distance. Where doubt exists as to the nearness of the ground water to the surface, the matter can usually be settled, for all practical purposes, by a few minutes' use of the pick and shovel.

While undoubtedly a good natural site can be improved by careful surface and subsoil drainage, in practice a camp should never be located in a situation where the latter procedure is actually required. Wherever deep drainage is instituted, tile drains, with a fall of one per cent., should be placed in rows thirty feet apart and at a depth of six or eight feet.

Adequate surface drainage is a most important factor in the maintenance of proper police in camp. A moist surface soil is quickly churned into mud by the constant passing of men and vehicles, and the company streets must be dry and firm to prevent the constant uncleanliness of the men and their habitations.

So far as soil moisture or ground water is concerned, the best site for the camp is afforded by a gravelly elevation; all low levels or soils which are retentive of moisture being avoided.

Soil Temperature.—Reflection of light depends upon the color of the soil; and the same factor, taken in connection with compactness of the particles, largely determines the absorption of heat by the earth—a white surface reflecting the heat rays and maintaining the air above it at a high temperature. Surface soil directly responds to fluctuations in the atmospheric heat, while deep layers react but slowly; soil temperature, in general, resulting from a combination of the daily and seasonal variations. At considerable depths, through the slowness of progression of the heat wave, the seasonal temperatures are reversed—the temperature in mid-winter being higher than in mid-summer. All soils have a lower specific heat than water, and hence more readily acquire heat. Wet soils, irrespective of their chemical nature, always absorb and radiate heat slowly, the rate depending upon the amount of water present. Hence dry sand absorbs heat much more readily than clay, and affords a warmer situation for cold weather encampments or winter quarters. In general, the temperature of dry soils is nearly 10° F. higher than in damp soils at the same depth. Organic matter in any soil is said to have a direct influence upon the absorption of heat, as it does with regard to soil moisture. The absorbing and radiating powers of soils are not necessarily equal, and, as a general thing, soils part with their warmth more rapidly than they acquire it. A grassy surface diminishes absorption and promotes radiation of heat; hence with a barren, sandy soil, the air above, through slow radiation, is oppressive at night as well as hot by day, and the selection of such a site for camping purposes, during warm weather, is palpably undesirable.

Different kinds of soils vary greatly in their capacity for retaining heat. According to Schuebler, the relative powers of certain soils as regards the retention of heat, that of sand being considered as 100, is as follows:

Calcareous sand	100.0	Argillaceous earth	68.4
Silicious sand	95.0	Pure clay	66.7
Gypsum	73.2	Calcareous dust	61.8
Light clay	76.9	Humus	49.0
Heavy clay	71.1		

From the above table it is readily seen that a sandy bed is usually to be preferred for the bivouac; not only from its greater dryness and adaptability to the outlines of the form but also because of its greater warmth at night.

Ground-heat favors the existence and multiplication of micro-organisms, and hence it is not strange that a direct relation between soil temperature, at a depth of three to six feet, and the prevalence of cholera has been observed. Dysentery and malaria are both dependent on an elevated soil temperature, and Ballard has noted that epidemics of diarrhœa occurred in England only when a temperature of 12° C., four feet from the surface of the earth, was maintained.

A ready but somewhat rough method of determining ground temperature consists in inserting a self-registering thermometer, packed in sand and enclosed in a tin tube, into a boring of the required depth.

Bacteriology of the Camp Site.—The bacterial life of soils natur-

ally varies greatly according to season, moisture, and other environmental conditions. According to Poore, the number of micro-organisms in one cubic centimeter of pure sand was 8,326, while it was 475,282 in a virgin peat, and 115,014,492 in the same amount of soil from the trench of a sewage farm; but whatever be the nature of the soil, the number of micro-organisms was found to diminish as the depth increased.

Kramer, in examining a clay soil highly charged with organic matter, obtained the following results:

Depth in meters.	Number of micro-organisms per gram of earth.	Depth in meters.	Number of micro-organisms per gram of earth.
0.20	650,000	1.20	5,600
0.50	500,000	1.40	700
0.70	276,000	1.65	a few.
1.00	36,000		

In the absence of suitable pabulum the bacterial life of soil, in general, is not large, and varies directly with the amount of organic matter present. Robertson and Gibson found that soil bared of grass and inoculated with typhoid bacilli soon became sterile unless frequently sprinkled with a nutrient solution, in which case the bacilli persisted at the end of six months. The organisms were able to penetrate downward into the soil to a depth of three inches, or grow upward to an extent of fifteen inches—vegetation retarding or preventing its development. Sandy or peaty soil was found by them to be strongly hostile to the growth of the typhoid bacillus, while clay and gravel favored its development. According to the medical report of the local government board of London, for 1898, temperature has little influence on the vitality of the typhoid bacillus, provided the ground remains moist. In an artificially polluted soil the bacillus maintained its existence for 456 days; and at the end of this period, after having been dried and reduced to dust, it still remained in viable condition. Karlinski has found that the typhoid bacillus may exist in putrid fæces for as long as three months. As regards cholera, it was found by Dempster that comma bacilli died out by the third day in dry sand, although in moist earth they were alive on the one hundred and seventy-fourth day. Peaty soil appears to destroy rapidly all pathogenic bacteria, irrespective of moisture, and, to a certain degree, regardless of organic contamination.

From a bacteriological standpoint it is evident that the selection of pure, dry, sandy soil for the camp site is eminently desirable. Such soil exerts an unfavorable influence upon the perpetuation of pathogenic micro-organisms, and they are rapidly overcome in the struggle for existence by the saprophytic forms, which find therein a more congenial environment. The pollution of the camp area with organic material is a powerful and necessary factor in the propagation of typhoid bacilli and other pathogenic bacteria, and undoubtedly is the chief factor in rendering disease epidemic in such camps as are carelessly policed or have been long maintained in the same situation. The vigorous upward growth of the typhoid bacillus renders it apparent that a superficial coating of earth, even several inches in depth, will not retain this micro-organism in an innocuous condition below the surface of the ground, and hence more careful attention to latrines becomes necessary. It would seem readily possible that typhoid bacilli, when covered with earth in a trench latrine, after reaching the surface through

their development upward and undergoing partial desiccation, may be carried up by air currents and inhaled or distributed upon food or water destined for consumption by the soldier.

Vegetation.—The presence of vegetation exerts a marked influence upon the healthfulness of the camp site, through the diminution of soil moisture, the tempering of thermometric changes, and the rapidity with which the nitrogenous products of decomposing organic matter are, by it, appropriated and utilized. In its luxuriance, vegetation depends upon the activity of putrefactive processes occurring in the soil, due to conditions implying the co-existence of heat, moisture and organic material in varying proportions. Excessive and rank vegetable growth indicates a high degree of soil moisture. While surface evaporation from the soil is retarded by its presence, the evaporation from the vegetation itself may be much greater in amount.

Trees have a pronounced effect in modifying extremes of temperature. In hot climates they prevent the heating of the ground by the interception of the solar rays, while in cold countries they check the force of air currents and afford excellent protection from inclement winds. Trees are powerful agents in the reduction of soil moisture, while by their roots they prevent washing of the soil and impede the passage of ground water. They afford considerable shelter for the bivouac—a fact put to practical use by the armies of the ancients and later by the troops of Napoleon. Experience appears to demonstrate that a belt of tall timber has an effect in reducing the liability to malarial infection, and hence such a screen should preferably intervene between the camp and a marsh if the occupancy of such an undesirable neighborhood become necessary. An abundance of trees in the vicinity of the camp is always desirable on account of the supply of fuel so afforded, while a few scattered through the camp itself afford grateful shade in warm weather. In practice, trees should rarely be removed for sanitary reasons, since no camp should voluntarily be located in such a heavy growth of timber as to render such action advisable. The loss of sunlight, stagnation of air, greater soil moisture and exhalations from the dead and decomposing leaves which cover the ground in dense woodland combine to render such a site unsuited for the purposes of a military encampment. Such localities remain damp until cleared and more thoroughly exposed to sun and air, and often appear to be especially malarious—besides which they are not devoid of the danger of accident during high winds.

Dense undergrowth is always unhealthful; since it favors the maintenance of soil dampness through interference with surface evaporation by air currents, as well as by directly protecting the ground against the drying influence of the solar rays. Should, however, the camp be of an ephemeral nature and intended only for a brief occupancy, it appears to be better, in a malarious country, that brush or shrubbery be not disturbed. In the case of a standing camp, the site and its vicinity should early be cleared of all undergrowth. The operation is preferably to be performed in the full heat of the day, and all rank vegetation, after being cut down, should be burned or removed before decay is established. The surface of the soil itself should not be disturbed. Sparse undergrowth, particularly if on a sandy or gravelly soil, is not necessarily to be destroyed.

A camp-site well covered with grass and possessing a strong turf is always desirable; but in permanent camps the carpet of herbage is soon destroyed by constant traffic. The maintenance in grass of exposed surfaces of the camp area largely obviates the discomforts of mud, dust, and reflected heat and light, and prevents washing of the soil by rains. The presence of moss, however, indicates dampness, and, for the same reason, ground covered with rank and wiry grass should be avoided. Briers and weeds should be cut down and removed, while it should scarcely be necessary to call attention to the desirability of destroying all "poison ivy" or "poison oak" in the vicinity of the encampment.

The sunflower and other plants of rapid growth have an excellent effect in reducing soil moisture through their great powers of absorption and evaporation. In Australia and Algeria the eucalyptus globulus is said to evaporate annually moisture equal to eleven times the rainfall on its ground area. Where the growth of vegetation of this character is free, a salubrious site may usually be expected.

II.

CAMPS.

Camps may be temporary and unsheltered bivouacs, may be formed of tents for longer occupancy, or may assume a semi-permanent character, in which case the use of huts or frame barracks becomes preferable.

In the establishment of a camp the following points, as incorporated in the regulations for encampments in the British army, are always to be considered:

1. The length of time that troops are to occupy the ground.
2. That order, cleanliness, ventilation and salubrity are to be ensured.
3. That means for passing through the camp are essential.
4. That a straggling camp increases the labor of fatigue duties, and impedes the delivery of supplies and the circulation of orders.
5. That the more compact the camp the easier it is to defend.

Plan of the Camp.—According to the tactics officially prescribed for use in the United States army, in the infantry camp, if in the presence of the enemy, troops bivouac in position. If safety permit, the tents may be pitched immediately in the rear of the line of stacks; the tents of the company officers being in the rear of their companies, and the tents of the field and staff in the rear of the center of the line of company officers. When not in the presence of the enemy, each battalion usually camps in column of companies at convenient distances. The tents of each company are in two lines, facing each other, or in one line, facing in the same direction. The tents of the company officers are arranged in line parallel to the flank of the column and at a convenient distance, facing the company street. The tents of the battalion commanders are opposite the center of their respective battalions in the rear of the line of company officers. The colonel is opposite the center of the column in the rear of the line of majors. The kitchens of the men are in line on the flank opposite the company officers, and may be either at the head or the rear of the column. The sinks for the men are outside the line of kitchens. The kitchens for the

officers are in the rear of the tents; the sinks for the officers being in rear of the line of tents of the field and staff. The width of the company streets and the streets in front of the company officers, majors and their

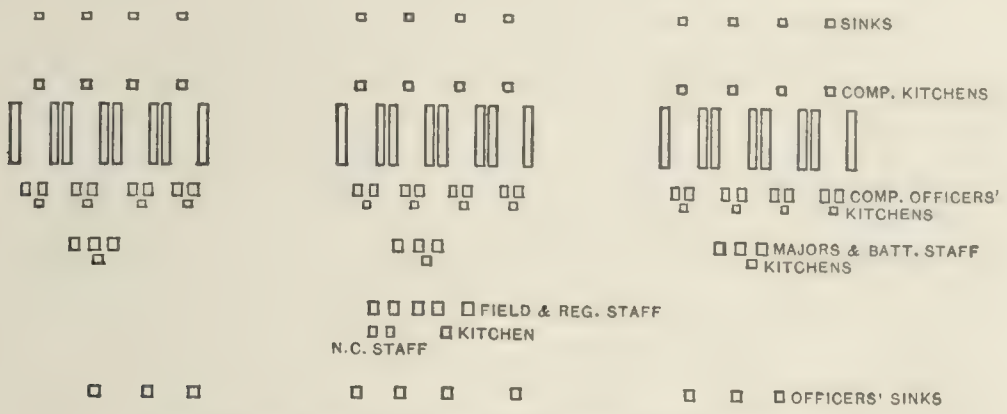


FIG. 128.—Plan of Camp for Regiment of Infantry.

staffs, and colonel and staff varies with the nature of the ground and the strength of the command. No instructions are laid down as to the area to be occupied by an infantry camp or the intervals to be maintained between the military units composing it.

In the establishment of the cavalry camp, the command is drawn up in line with intervals of 8 yards between troops; the men unsaddle and place their equipments 10 yards in front of the horses. The tents of the men are pitched in line, about 15 yards in the rear of the picket line; the intervals between troops being left free. The kitchen of each troop is near

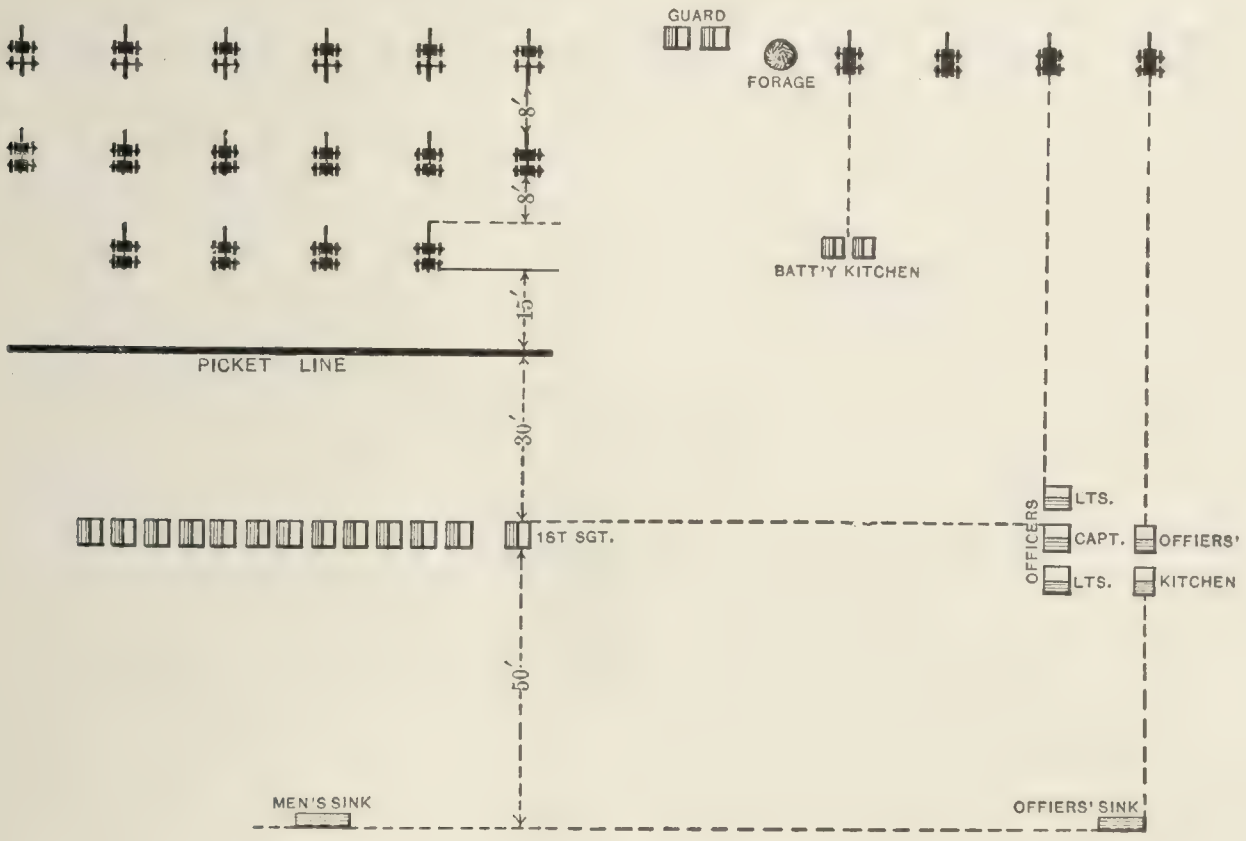


FIG. 129.—Plan of Camp for Light Battery of Artillery.

the left, in front of the line of tents, and the sinks are in front of the line of kitchens. The tents of the officers of each troop are about 30 yards

in the rear of the line of tents. The tent of the commanding officer is in the rear of the line of troop officers; together with the tents of the field and staff. The kitchens of the field and staff are in the rear of their tents, while the non-commissioned staff are in the rear of the kitchens. The

officers' sinks are in the rear of the camp. The squadron may also encamp in column of troops, the tents of the men being in line, in the rear of their horses, about half way between them and the horses of the troop next in rear. The tents of the officers are in line, parallel to and 30 yards from the flank of the column toward which the troops are dressed. The tents of the field, staff, and non-commissioned staff are arranged as before prescribed. The kitchens of the men are in line on the flank opposite the officers; the sinks being outside of the line of kitchens.

There are several methods by which a battery of light artillery may be encamped, and these may be interchanged or modified to suit circumstances or the nature of the ground. The plan shown in Fig. 129, however, is the one usually adopted. Where a battalion of light artillery is encamped, the guidons are established with a distance between them of 94 yards. The tent of the battalion commander is at a point 60 yards from the line of guidons, on a line passing 17 yards in rear of the guidon; each captain being 75 yards to the rear and 30 yards to the flank of his battery. The picket line is 15 yards in rear of the line of carriages and 30 yards in front of the men's tents. The cook tent and guard tent are on the line with the tents of the command. The sinks are 105 yards from the exterior flank, on the prolongation of the picket line. Officers' sinks are 60 yards in rear of the staff tents, which are located at intervals of 5 yards facing the interior flank.

It is evident that the location of the latrines in the infantry and cavalry camps has often brought them in highly dangerous proximity to the kitchens; and hence a general order, recently issued, providing for the establishment of the sinks at such distance from the kitchens as may seem advisable to commanding officers, cannot fail to be of sanitary advantage. It would be better, however, if a minimum distance between the camp and the sinks were officially laid down in orders.

For the establishment and arrangement of temporary or semi-fixed hospitals under canvas no instructions are provided, the matter being left to the discretion of the officer in command. Of the larger temporary hospitals, the general field hospital established at Montauk Point in 1898 may be taken as a type. This hospital had accommodations for 1,750 patients. The canvas was pitched on wooden frames—eight hospital tents being joined together to form a ward. This hospital was convenient of administration, but the wards were too crowded together and were badly oriented. With these enceptions the plan was excellent.

From a hygienic standpoint tents should never be arranged in double rows; and in all instances the plan of the camp should be suited to the terrain, and the different arms of the service encamped on ground best adapted to their special needs. In hot weather the front of an encampment should be toward the north and east, and in cold weather toward the south and east. It is also advisable that camps should face away from prevailing winds.

Area of the Camp.—All military encampments are densely populated, and hence every effort of the sanitary officer should be toward their expansion—as large an area as can be properly policed being desirable. The mere aggregation of human beings exercises a powerfully depressant influence on vital resistance, and it has long been demonstrated that the death

rate in different sections of large cities bears a direct relation to the density of their population. As this is true in civil life, so it is more so in the military establishment; where sanitary requirements are often disregarded, and where every facility is present for the propagation of infectious

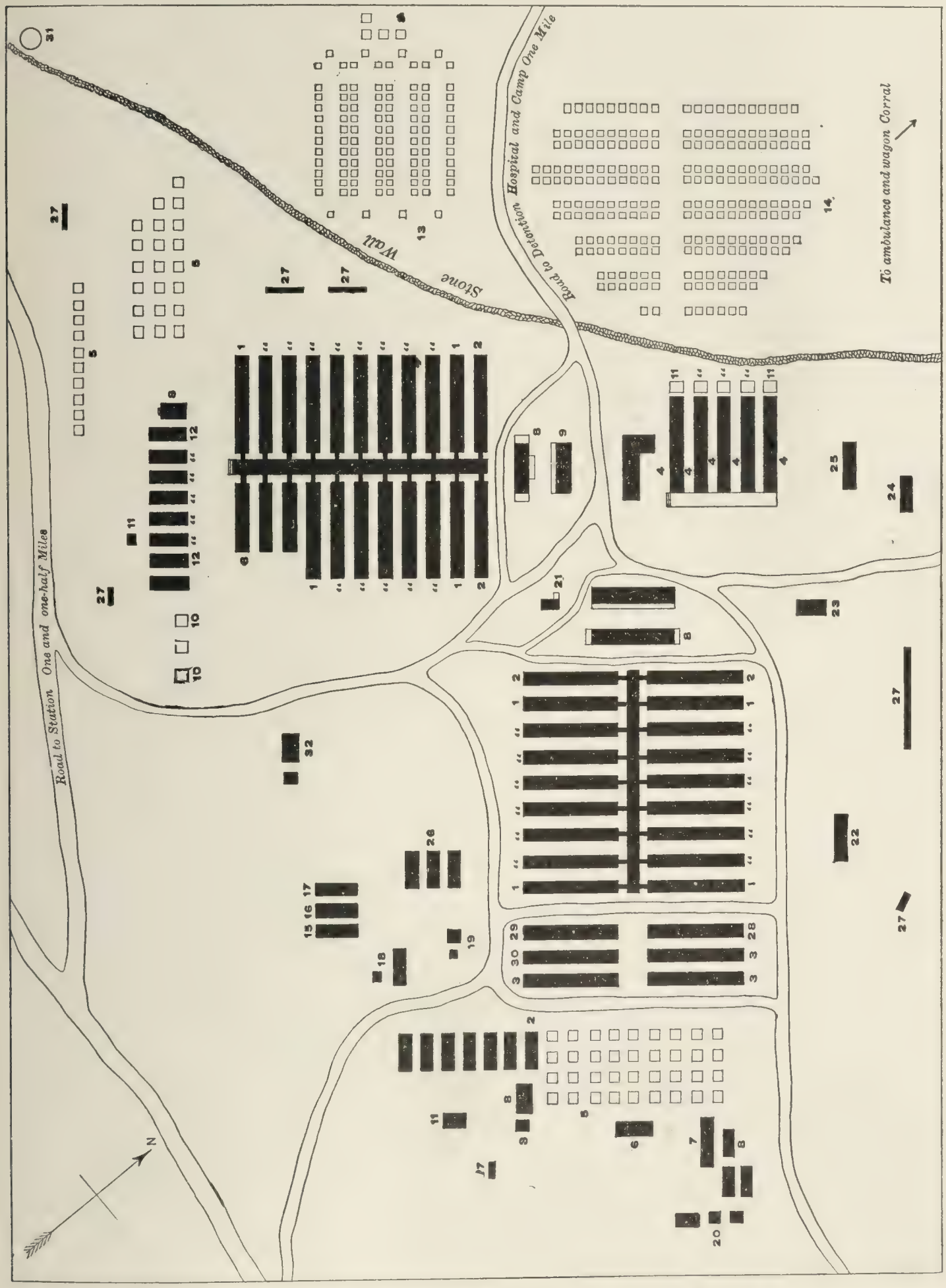


FIG. 130.—Ground Plan of General Field Hospital at Montauk Point. 1, Wards; 2, mess halls; 3, storerooms; 4, convalescent wards; 5, officers' quarters; 6, chief surgeon; 7, officers' mess; 8, kitchens; 9, commissary and ice house: 10, priests' tents; 11, bath tent; 12, tents for Sisters of Charity; 13, camp of guard; 14. tents of Hospital Corps men: 15, post and express office; 16, chapel and reading tent; 17, quarters for strangers; 18, 19, relief societies; 20, store tents for relief societies; 21, disinfecting tent; 22, isolation ward; 23, store tent for disinfectants; 24, dead house; 25, contagious diseases: 26, extra nurses' quarters; 27, latrines; 28, operating tent; 29, dispensary and store tent; 30, general office; 31, water tank; 32, guard tents.

disease, through the intimate relationship and frequent contact necessarily implied by military life.

In foreign armies the camp area is a matter of official regulation, and hence too great crowding is impossible. In the British service the camp spaces are divided into the maximum and minimum, between which points commanding officers are entitled to use their own discretion. While the regulations of 1863 established the ground space for encampments in our service, the matter has since been ignored, and neither tactics nor regulations now contain any definite instruction for the guidance of officers, other than those of light batteries, in this most important subject. Hence tents may be widely scattered or closely crowded; but the practical result of such latitude of choice is that overcrowding is invariably the case wherever a large number of men are encamped together.

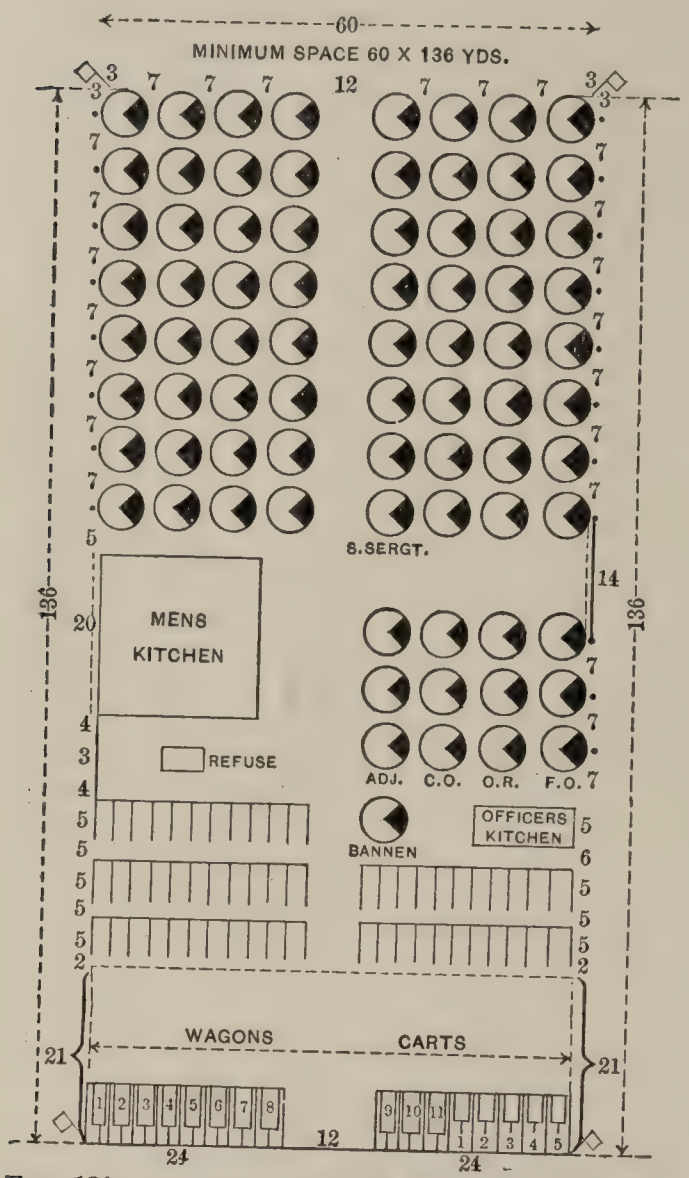


FIG. 131.—Arrangement and Minimum Camping Space of British Infantry Battalion.

The tactics of 1863 prescribed that the length of a camp should depend on the line of battle front which the command presented—an arrangement obviously rational. With the old regimental strength of 600, officers and men, a frontage of 22 inches per man, with double rank, gave a color line of 150 yards, or a company frontage of 15 yards. Each regiment also had a vacant margin of 12 yards on each flank, thus giving 174 yards to each regiment. The regulations prescribed that the tents of the men should be pitched perpendicular to the color line, and ten paces from it. Each company was disposed in two opposing files with a street between; this street, together with the ground on which the tents were pitched, constituting the company area. Each row, for the regiment of 600 men, contained about 13 shelter-tents, so pitched as to give the company street a length of 50 paces (42 yards) and a width of 9 yards. Whenever the frontage of the camp was narrowed, it was done at the expense of the company streets; a width of 5 paces being the minimum of condensation allowed by regulations. If further narrowing of front was required, it was necessary to pitch camp in columns of division; the tents of each company being arranged in a single row on one side of the company street. The kitchens were parallel to the color line and 20 yards from the rear rank of the tents, and the company officers were 20 yards from the kitchens. At a distance of 20 yards behind a line drawn through the kitchens of the company officers, were located the tents of the field and staff. The officers' sinks were 100 paces in the rear of the non-commissioned staff; the sinks of the men were 150

paces in front of the color line, and the advance guard was located 50 paces in front of the sinks. This arrangement gave a superficies of 62,292 square yards for the regimental encampment, or 104 square yards for each of the 600 men. When the frontage of the camp was narrowed to the minimum authorized by regulations, the per capita ground space was reduced to 74 square yards.

The accompanying diagram by Smart (Fig. 133) illustrates the encampment of two infantry divisions and four batteries of artillery, in all 18,620 men, as disposed under the regulations of 1863. The regiments have their minimum front, making a battle line of 2,160 yards and a depth of 1,566 yards. This arrangement gives a superficies per capita of 182 square yards, or a density of 17,020 men per square mile.

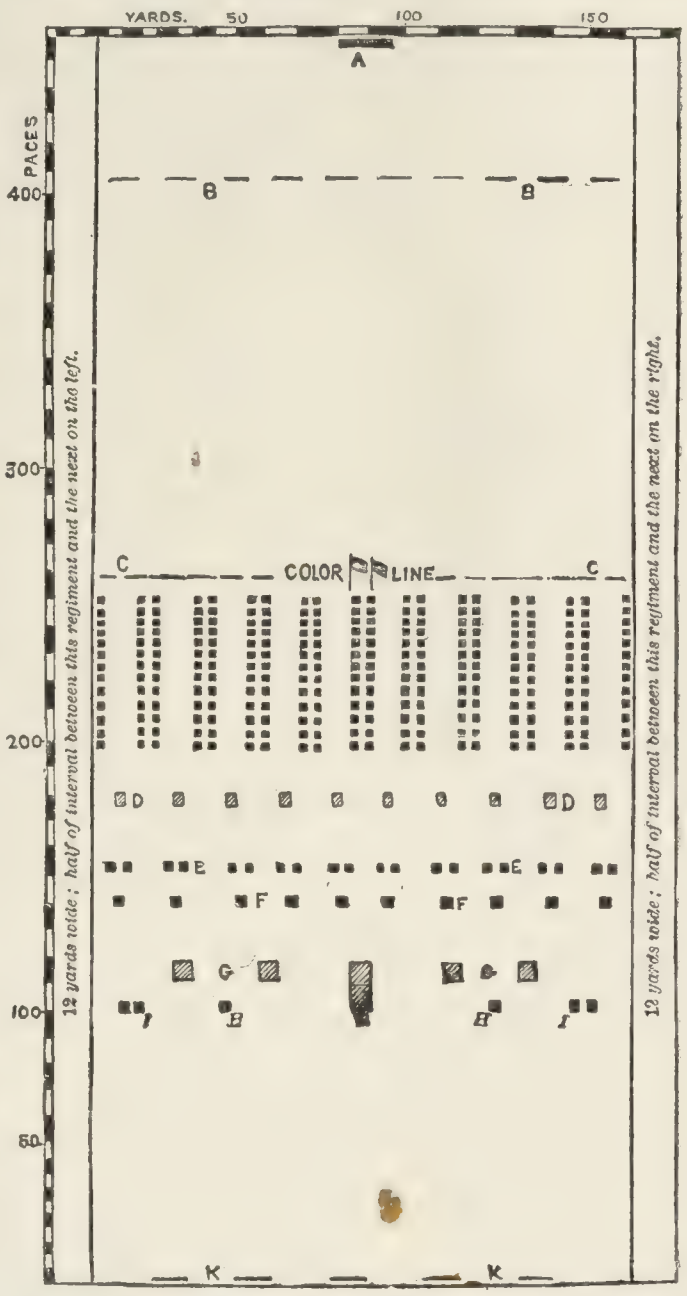


FIG. 132. — Regimental Encampment, United States Army, Under Regulations of 1863. *A*, Advance guard; *B*, men's sinks; *D*, company kitchens; *K*, officers' sinks. (After Smart.)

With the increase of the army in 1898 the maximum strength of an infantry regiment, officers and men, amounts to 1,359 souls—or more than double the old strength. If encamped in accordance with the regulations of 1863, the new regiment of twelve companies would have a frontage of 363 yards, and each row of tents would have a depth of 87 yards. This would give a total superficies of 158,208 square yards, or 116 square yards of surface to each man.

From the foregoing figures it is evident that the dangers of overcrowding in a properly spaced camp exist rather within the tent than without it, and that the sufficiency of the camp area depends largely upon the manner of its occupation. In the present lack of regulations on the subject it is of course possible for a commanding officer so to contract his camp as seriously to interfere with sanitary requirements. In some of the volunteer camps during the war with Spain the tents were crowded so closely together as to be tied to each other at the sides, while the tents of different companies almost touched each other at their backs.

Mounted troops, from the nature of their branch of the service, require proportionately much more ground for the establishment of their camp than do foot troops, and hence their camp area is by no means as densely populated. Still, the discomfort and unsanitary conditions attached to the presence of a large number of horses, particularly in hot weather, will usually more than neutralize any sanitary advantages which might have accrued from the greater ground space.

Bivouacs.—The employment of the bivouac permits the possession of certain great military advantages, viz., increased mobility of troops, proximity to the line of march, compactness of camp, and hence readiness of assembly; but long continuance in the field without shelter during inclement weather greatly impairs the efficiency of the command. Napoleon habitually required his troops to bivouac during campaign—a practice to which the medical writers of the time largely ascribed the great sick-rate and mortality prevailing among the French troops. In warm clear weather and on a dry soil, however, the bivouac may be temporarily employed without the production of ill effects.

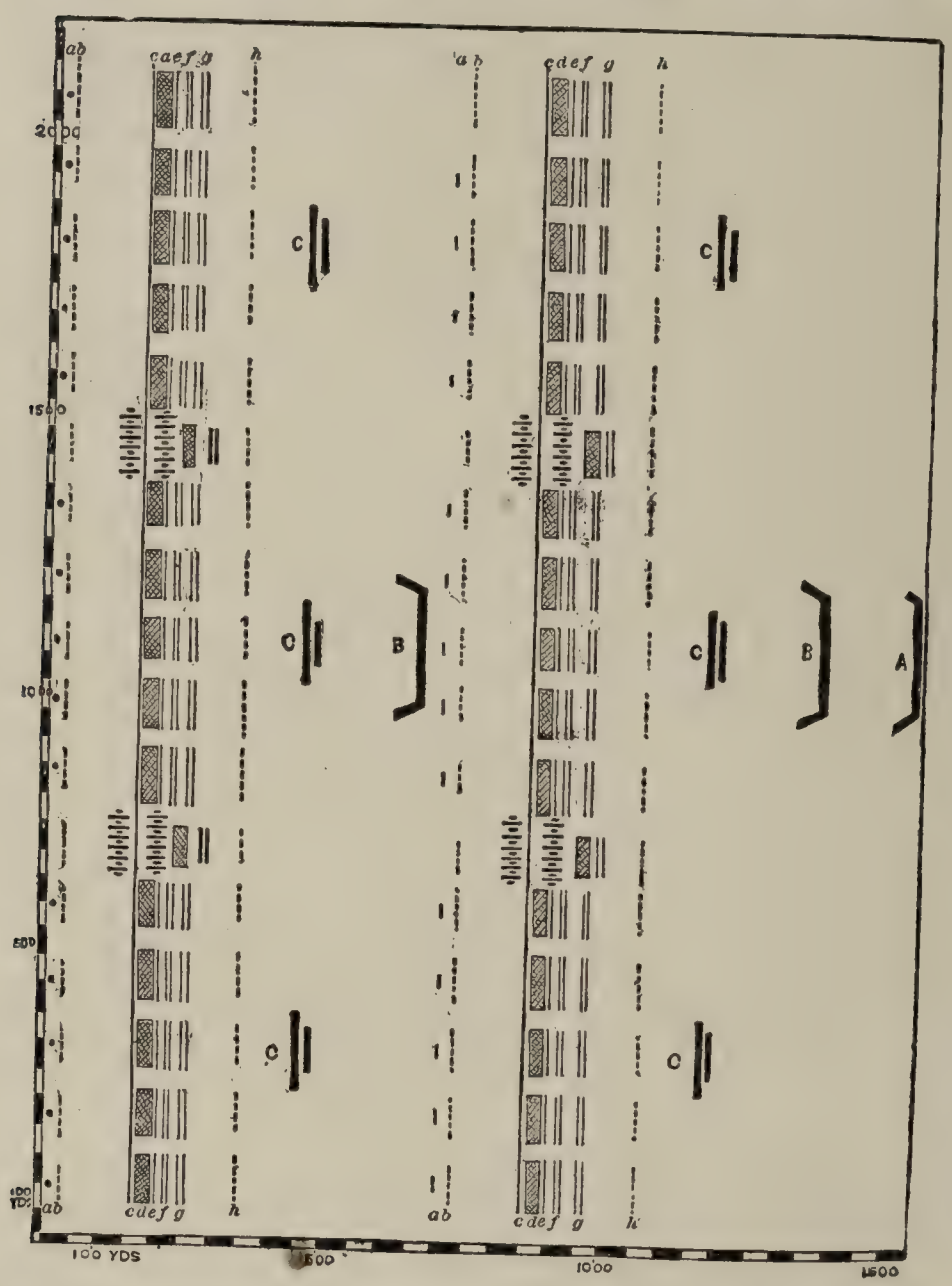


FIG. 133.—Encampment of an Army Corps Under Regulations of 1863. *A*, Army headquarters; *B*, division headquarters; *C*, brigade headquarters. *a*, Advanced guard; *b*, men's sinks; *c*, color line; *d*, area of men's quarters; *e*, company kitchens; *f*, company officers; *g*, field and staff; *h*, officers' sinks. (After Smart.)

Bivouacs are encampments without the protection of tents or huts, and the principles for the selection of the camp site, already discussed, are of the greatest importance in their establishment. It is generally well, in the absence of some more potent reason to the contrary, to bivouac among trees—since standing timber affords protection from the winds, material for shelters and fires and a screen from the observation of the enemy. The bivouac should always be established in order and in accordance with a regular plan. Straggling should be prohibited, and the soldiers usually required to occupy their own company and squad areas; but the occupation of neighboring buildings by a part of the command, under proper authority, may at times be advantageously permitted. In the bivouac of the Spanish army, which is a fair type of the arrangement employed in various European services, each battalion of 1,000 men occupies a space having a frontage of 110 meters and a depth of 170 meters. The companies are encamped in column of sections, and each section is permitted to kindle six fires, to each of which ten men are allotted. Such a fire, with its circle of soldiers, occupies a space five meters in diameter; four meters of free space being preserved between groups. The company officers bivouac on a line bisecting the camp trans-

versely. The latrines are located according to the discretion of the commanding officer, but are required to be placed at a distance of not less than 60 meters from the troops. This arrangement gives a ground space of 18.7 square meters to each man.

A slight amount of shelter will protect against wind, and for this pur-

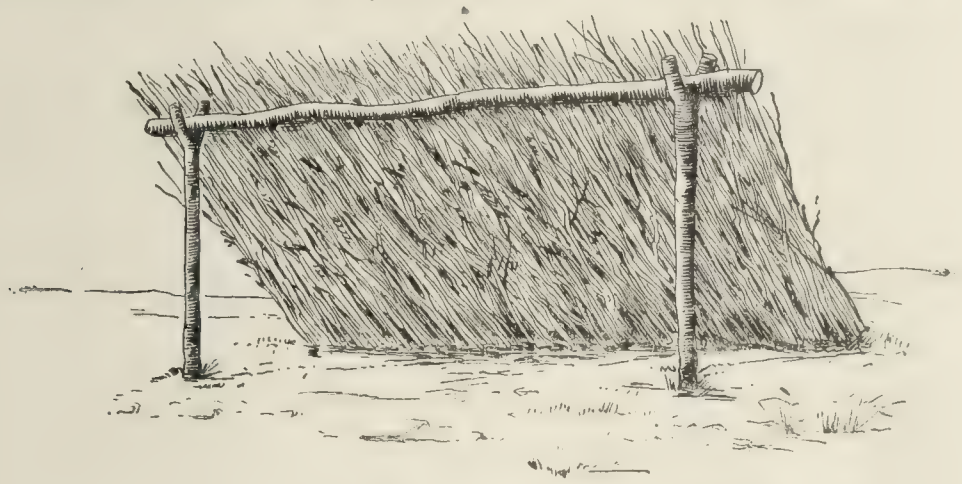


FIG. 134.—Brush Wind-break for Bivouac.

pose walls, hedges and undulations of the ground may be excellently utilized. When trees are available, a convenient shelter for the bivouac may be constructed by resting a pole on two forked uprights raised several feet above the ground, against which leafy branches, thick end up, are piled at an angle of 45° on the windward side. In the absence of this material, reeds or long grass may be employed—or dirt or stones may be heaped up to the necessary height. Usually the ground upon which the soldier intends to sleep should not be excavated or disturbed. In European armies, when no shelter tent is carried, earth and brushwood are together utilized in the construction of a circular bivouac. The turf is carefully cut out around the area intended to be enclosed, and placed so as to revet the in-



FIG. 135.—Arrangement of French Bivouac.

terior slope; earth being thrown against it until a bank two or three feet high is made. An entrance is left to leeward, and the earthy ridge is thickly planted with branches or shrubs. Such a bivouac ordinarily has an interior diameter of 18 or 20 feet and can comfortably accommodate fifteen men. A small fire is usually kindled in the centre of the enclosed area; the men disposing themselves, like the spokes of a wheel, with their feet to the fire. In the German army a narrow trench is usually dug around

the central fire to limit the danger of accidents. In the bivouac of light artillery troops, the men sleep under the guns and caissons, where ample protection is afforded by the paulins. Each paulin is 11 feet square and each gun and caisson is provided with two such pieces of canvas.

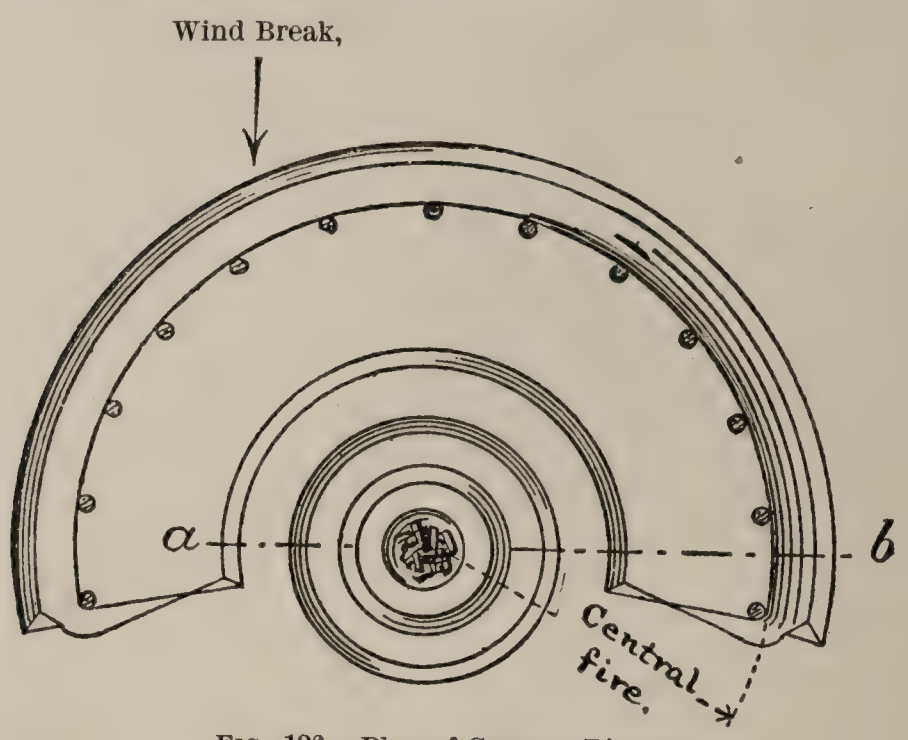


FIG. 136.—Plan of German Bivouac.

Where the shelter-tent forms a part of the equipment of the soldier and is habitually carried, as in the United States service, the necessity for the bivouac will scarcely occur unless in the vicinity of the enemy; and hence in its employment military and not sanitary considerations will usually be of the most importance. With our troops the bivouac without shelter-tents will rarely be required; nor should it be, except on the eve of battle.

Cantonments.—Troops in the field may be quartered in the houses available in the district occupied; provided the resources of the country and strategical and tactical considerations admit of such disposition. They are then said to be in cantonments. Such method of sheltering troops has rarely been employed in this country, and here the term, by a perversion of meaning, has come to imply the occupancy of such rude yet roomy and substantial structures as have been built by soldier labor for supposedly temporary occupation.

The manner in which cantonments are employed depends upon the degree of concentration in which it is necessary to maintain a command; for few countries are so densely populated as to allow of large bodies of troops being quartered in houses, with some regard for the comfort of both the men and inhabitants, without distributing the former over a wide area. Usually troops in cantonments must make the best of the area assigned to them; as many men as possible finding shelter in houses and outbuildings, while the remainder bivouac in gardens and fields—care being taken that the roads are left vacant to ensure ready communication. In estimating accommodation for ordinary cantonments, a certain number of rooms, preferably those of the upper floors, must be reserved for the use of the inhabitants. The Germans, in placing troops in cantonments, group the houses of the district to be occupied into several classes. The capacity of a representative of each class of dwelling is then determined, and the number of houses of each class estimated; whence the total accommodations can readily be calculated. In general, in rooms more than 15 feet wide, but having a width of less than 25 feet, two men can be assigned for each yard of length; while for rooms of 25 feet or more in width three men may be accommodated in each linear yard. This of course implies crowding, and the arrangement must be only temporary. The French rule pro-

vides for a space 2 meters square (42 square feet) for each soldier, which is nearly as large as the area allowed in barracks.

When troops are placed in cantonments the water supply is frequently restricted and the sanitary arrangements of the inhabitants will rarely suffice. Careful supervision of the water should therefore be instituted, and latrines should be at once provided, similar to those used in the field.

The cantonment system is evidently impracticable in the presence of epidemics; while in prolonged campaign, considering the large numbers of troops involved in modern warfare, it will be impossible even under the best of circumstances to provide sufficient shelter by such means. While the billeting and cantonment of troops is habitually practiced among European nations in time of peace, no such procedure would ever be tolerated in the United States. For troops at home, therefore, the subject possesses only theoretical interest, although it may have a practical importance in the occupation of foreign territory.

Shelter-Tents.—The piece of canvas known as the shelter-tent half forms part of the personal equipment of the soldier, and is not included in the allowance of tentage issued to troops when not occupying barracks. It is provided for usage of a purely temporary character, and is intended to afford protection from the elements whenever the employment of more burdensome shelter is impracticable. The shelter-tent camp, therefore, occupies a position intermediate between the simple bivouac and the more substantial tent encampment.

A tent similar to the shelter-tent was in use in the British army in 1750, but was re-invented by the French troops in Algeria about a century later; the bedsacks which were issued in the latter service at that time being split open, fastened together in couples and utilized as shelters. Introduced into our army early in the Civil War, the shelter-tent at once became popular among troops, and this position it has maintained down to the present time. The shelter-tent is light—a most essential quality—is readily pitched, well ventilated and never overcrowded. By its employment the hardships of the bivouac are avoided, recourse to the cantonment system becomes unnecessary, and the command is rendered largely inde-

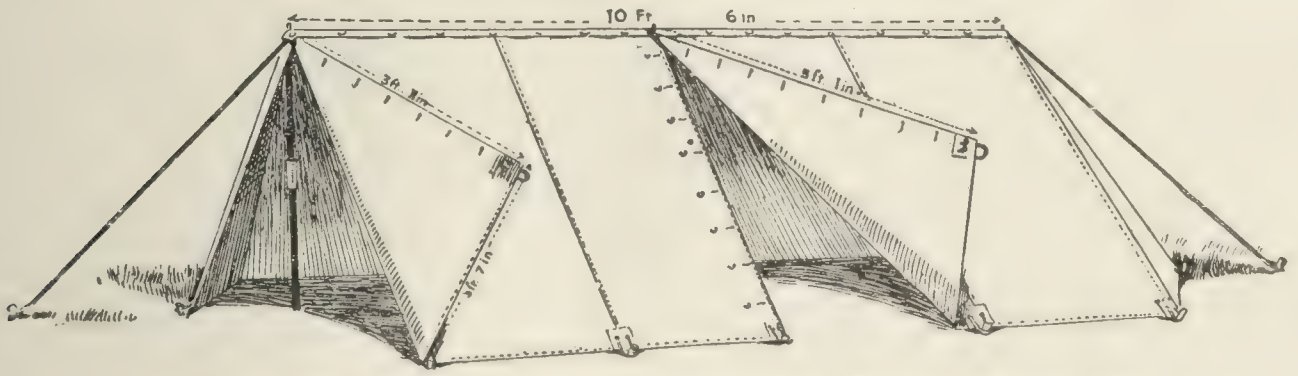


FIG. 137.—New Style Shelter-Tent. Two double sets are pitched together.

pendent of the movements of the wagon train. It serves an excellent purpose, in the protection of troops, not only when pitched upon the ground but also when used as a roofing for habitations with solid walls. It is not, however, a sufficient protection for a winter campaign. As usually carried by the soldier, it is rolled around the blanket in the form of a long cylinder

and slung from one shoulder to the opposite hip; the free ends being tied together with the guy rope.

The old style shelter-tent was scarcely long enough properly to protect the soldier. Although slightly wider than the model recently adopted, it possessed no means for the closure of the ends in stormy or windy weather. Brush, branches or rubber blankets were often used for this purpose; although sometimes a third man was accommodated in the tent and his piece of canvas used to stop up the exposed end. While the buttons on both sides of the old shelter-tent permitted the pitching of an indefinite number in common, as a matter of fact such an arrangement was



FIG. 138.—Old Style Shelter-Tent.

rarely resorted to; the men usually preferring to tent in pairs except during very stormy weather.

The recently adopted shelter-tent is made of 8-ounce duck and is 65 inches long on the ridge and 61 inches wide. The closed end measures 3 feet 11 inches from ridge to base, and 3 feet 7 inches along the base. There are nine buttons and button-holes along the top; the buttons, of white metal, being $7\frac{7}{8}$ inches apart and 3 inches from the edge. The sides of the tent have seven buttons and button-holes; the button-holes being worked half an inch from the edge, while the buttons are $3\frac{1}{2}$ inches from the edge. Along the closed end there are the same number of buttons and button-holes, spaced about 6 inches apart. Each half tent is furnished with a one-quarter inch Manila guy-line, 6 feet 7 inches long, and 4 foot-stops, by which the canvas may be pegged to the ground. A set of shelter-tent poles consists of two uprights, about one inch in diameter, which, when joined, make an upright 46 inches long, with a spindle one inch long at one end. The poles are joined by means of a tin socket four inches long. The weight of the shelter-tent half is 2 lbs. $8\frac{3}{4}$ oz., while the set of pins weigh 3 oz. and the pole 9 oz. This brings the total weight of the individual equipment up to 3 lbs. $4\frac{3}{4}$ oz.; or considerably less than the weight of the shelter-tent used in foreign services. During campaign in a wooded country, however, this weight is still further reduced; since troops are prone to discard the poles and pegs as being an additional and superfluous burden, and to rely upon the undergrowth in the vicinity of the camp-sites to furnish substitutes.

In the new shelter-tent no more than four individual portions can be pitched together. The adjustment of the end-pieces makes the length amply sufficient, while the comfort of the occupants is considerably increased through the perfect protection afforded from driving winds and rains and the increase in the available ground space. The two halves of the tent, when joined and pitched with uprights of 46 inches height, give

a spread at the base of about $7\frac{1}{4}$ feet, and provide a sheltered area of about 20 square feet for each of the two occupants. The cubic air space is of no importance when only two men tent together, since one end of the shelter is necessarily left open. It becomes, however, a serious matter if four of the new shelter halves are pitched together; since both ends may then be closed and the cubic air space rendered quite insufficient for the four inmates. The tenting of men in squads of four should therefore be discouraged; and, whenever permitted, it should be the care of officers to see that both ends of the tent are at no time tightly closed.

No shelter-tent is issued in the British service except to those troops serving in South Africa; when each man carries a canvas sheet $5\frac{3}{4}$ by $5\frac{1}{4}$ feet, together with a triangular piece $2\frac{3}{4}$ feet high and having a base $5\frac{1}{4}$ feet wide for the closure of the ends. The upright has a height of 48 inches. The English shelter-tent equipment weighs 6 pounds 14 ounces per man —a serious defect which has been a strong factor in preventing its wider use. Wolseley calls this tent a bad imitation of the French model, and says that it fulfils few of the purposes for which it was originally designed.

The shelter-tent was used in the French army in the war in Italy, the war in Mexico and the war of 1870–71. On account of its weight it was discarded after the latter war, with the expectation that troops in campaign could usually find shelter in cantonments; or, failing in that, could bivouac without injury. It is now issued only to troops serving in Algeria and to the Alpine Legion. The tent is made of hempen canvas and is almost identical with our old-style shelter-tent, the ends being unprotected. The weight of this tent is about 4 pounds per man. Each piece is $5\frac{1}{2}$ by $5\frac{1}{4}$ feet, while the uprights are 40 inches in height. A shelter-tent similar to the French model, but slightly less in size, is now in use in the army of Holland.

While the shelter-tent has, in the past, been rarely employed in the German service, a model is now used consisting of a piece of water-proofed

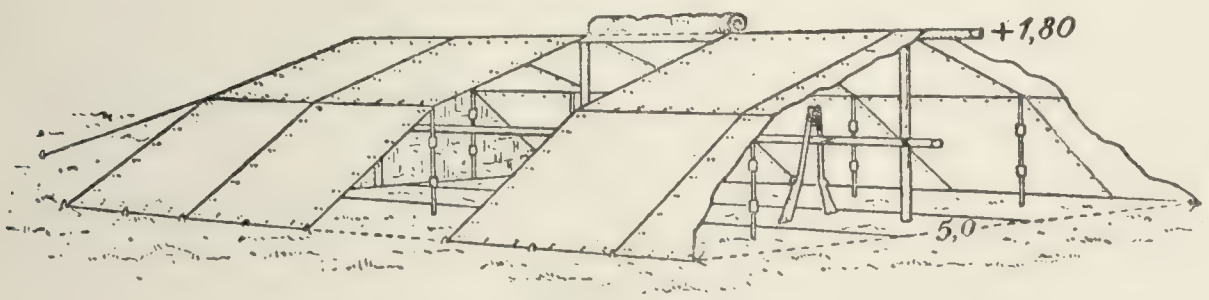


FIG. 139.—German Shelter-Tent.

brown material 1.5 meters (5 feet) square; furnished with eyelets, buttonholes and aluminum buttons and having a weight of $3\frac{1}{3}$ pounds per man. During the march this tent can be used to protect the soldier against rain, being fastened around the neck and waist. Two men can pitch their squares together; but usually a number unite their canvas into one shelter. In the latter instance, four individual pieces are generally joined to make a single long sheet. This is supported at the middle by a ridge having a height of 1.8 meters, while the ends are pegged to the ground at a distance of 5 meters from each other. Half-way between the central ridge and the pegs the canvas is supported by small uprights carried for the

purpose. Sections similar to the above may be added indefinitely—each section readily accommodating four men. The canvas may also be pitched over a frame, so as to form a shelter with a roof and back but open at the front and sides. In fine weather or summer the shelter-tent is not pitched, the men sleeping upon it. A shelter-tent somewhat similar to that of the Germans is used in the Spanish army. Each tent is required to serve for the shelter of six men and has a length of 3.30 meters and a breadth of 2.50 meters. The Japanese troops, in the war with China, carried a shelter-tent of water-proof cotton 3 feet 3½ inches by 4 feet 7 inches. The Russian shelter-tent also resembles that of the German military service.

The Austrian army has a somewhat different shelter-tent, weighing 3¾ pounds per man. It is made of cotton duck, each piece being lozenge-shaped and having a length on the side of 2 meters. The tent may be pitched so as to accommodate a large number of men, but usually only two men combine their canvas. Each piece of cloth is provided with an aperture at one obtuse angle, capable of receiving the bayonet and protected from tearing by a metal rim.

The tent may thus be supported by the use of the rifle as a central upright, or small jointed rods may be employed for the purpose. When pitched, the tent forms a pyramid having a rectangular base 2 meters square and a height of 1½ meters. It accommodates two men, or in an emergency three, and gives a sheltered area of 4 square meters. The use of the rifle as a support would seem to be highly inadvisable from a military standpoint.

Tentage in General.—The question of tentage in the field depends to a certain extent upon climate, but mainly upon the availability of transportation. From a military standpoint it is all the better if tents can be dispensed with, since they add considerably to the train of an army and thus seriously impair its mobility. In active campaign during wet weather, when the difficulties of transportation are greatest, tentage is frequently not at hand when most desired. Hence it is, in time of war, that tents find their field of greatest usefulness in camps of a semi-permanent character; during the mobilization and organization of troops and temporary lulls in hostilities.

In general, the requirements of a good military tent are that it should not be of too great weight, should be quickly and securely pitched and capable of being promptly taken down and packed for transportation. It should not be too large, yet, at the same time must be of sufficient size to afford an adequate air space; it should be durable, easily ventilated and aired and possess stability in high winds. It should thoroughly protect the inmates from the inclemencies of the weather, and should be so shaped as to make all portions of the enclosed area of practical availability.

The material of which tents are made for the military service of the United States is eight, ten, and twelve-ounce cotton duck. This is less costly than canvas of other material, and is also less permeable to water and less liable to retract in the presence of moisture. Linen tents have in times past been tentatively issued by the Quartermaster's Department, but have not given satisfaction. In European armies, however, hempen or linen canvas is usually preferred. In the German and other foreign

services the material used for shelter is often artificially rendered waterproof; usually by treatment with acetate of aluminum. This procedure is undoubtedly of great value during hard storms, particularly when applied to tentage with which no flies are employed, and should certainly be adopted in our service. Where water-proofing is used, the material can be made much lighter and thus a great saving in weight is possible.

The color of the ten and fifteen-ounce duck tentage now being issued is of light drab or dusty-brown; the glare of bright sunlight being thus greatly subdued and rendered much less trying to the eyes than in tents made of white canvas. This diminution in the intensity of light, always of importance, is of particular value in connection with hospital tentage. The same result is attained in foreign services by the use of interior tent linings made of light blue cloth. The drab tent has also the military virtue of being inconspicuous and hence less readily attracts a hostile fire; while it presents a neater and more uniform appearance after long exposure to the dust of the camp or to the handling incident to prolonged marching or campaign. The deadening or darkening of the canvas is not sufficient to increase very greatly the absorption of heat rays, although for ordinary camp usage in a warm climate a combination of a white fly with the darker colored tent is certainly more desirable. With a dark fly the present drab tent is insufficiently lighted during cloudy or stormy weather. Unfortunately the brown dyes used on our tentage in the past have bleached rapidly on exposure to the weather.

In all armies the tent space afforded each man is very limited, and in our service the official allowance of tentage is not sufficient to meet the demands of hygiene. Hence it is fortunate that about one-fourth of the authorized occupants of a tent are, in practice, constantly absent; either sick in hospital, on guard or detached duty or otherwise employed. In France the tent space is calculated at the rate of 11 square feet for each foot soldier and 28 square feet for each cavalryman. In our army the allowance has varied with the tent employed, as well as with the conditions of climate and service. Until lately the United States infantryman, in the common wall tent, was entitled to only $8\frac{1}{2}$ square feet of surface upon which to dispose his person and equipment; but this space has been doubled under the provisions of a recent order. This increase in the allowance of ground space, combined with a constant tendency toward a reduction in the numbers of the tent squad, is of the greatest sanitary value and also largely promotes the physical comfort of troops.

Ground and air space being equal, the use of small tents is preferable to the employment of larger canvas; since by the former the danger of crowd-poisoning is much diminished by scattering the men, in smaller groups, more equally over the company area.

United States Army Tentage.—The common tent, better known as the wedge or A tent, was much used during the Civil War, but is fortunately no longer employed for the shelter of troops. It was not provided with facilities for ventilation, and afforded a floor space but 17 inches wide and a cubic air space of 18 feet to each of its six occupants. It is now issued, in the proportion of one for each troop, battery, company or regimental hospital, for the protection of subsistence stores, and is also much employed for the covering of officers' latrines.

An improved common tent, having a wall, has recently been issued. This, when pitched, has a height of 6 feet 10 inches and a width of 8 feet 4 inches. The ridge has a length of 6 feet 11 inches, while the height of the side walls is 2 feet. The door is 5 feet 6 inches high, and

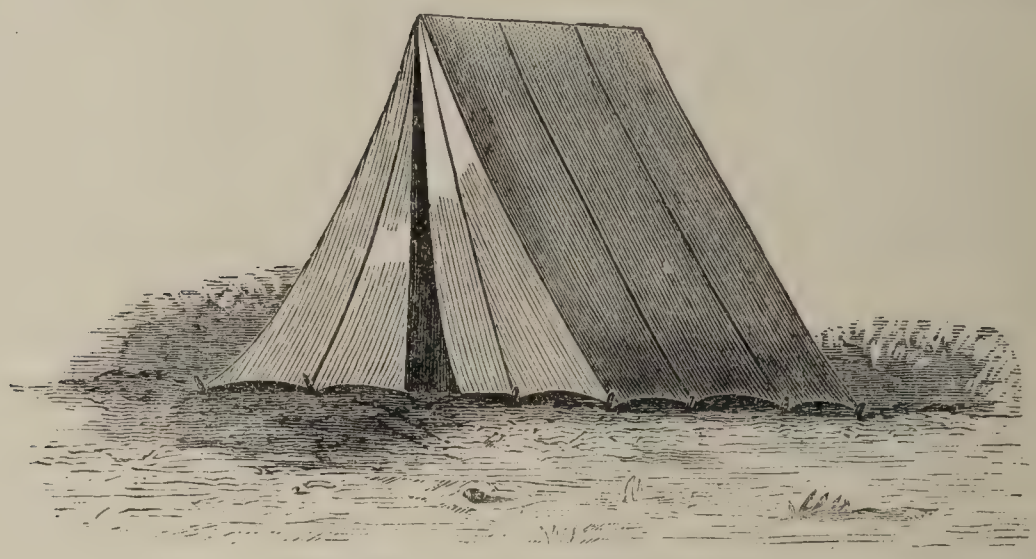


FIG. 140.—Common Tent, Old Style.

has a width at the top of 3 inches and at the bottom of 1 foot. The tent is made of ten-ounce cotton duck and is equipped with a sod cloth of $8\frac{3}{4}$ inches width. It is ventilated by two openings, one in front and rear respectively; each being 3 inches wide, 6 inches long and guarded on the inside with a flap or curtain. The tent is not provided with a fly, and hence is excessively hot in warm weather; the single thickness of roofing canvas, unless new, also does not prove an adequate protection against heavy or driving rains. To pitch the tent 24 tent-pins of 16 inches length are required. This tent contains a superficial area of 57 square feet and an air space of 250 cubic feet. The allowance was formerly four mounted men or six infantrymen, but this has recently been reduced to three men of any branch of the service. This recent allowance gives 83 cubic feet of air

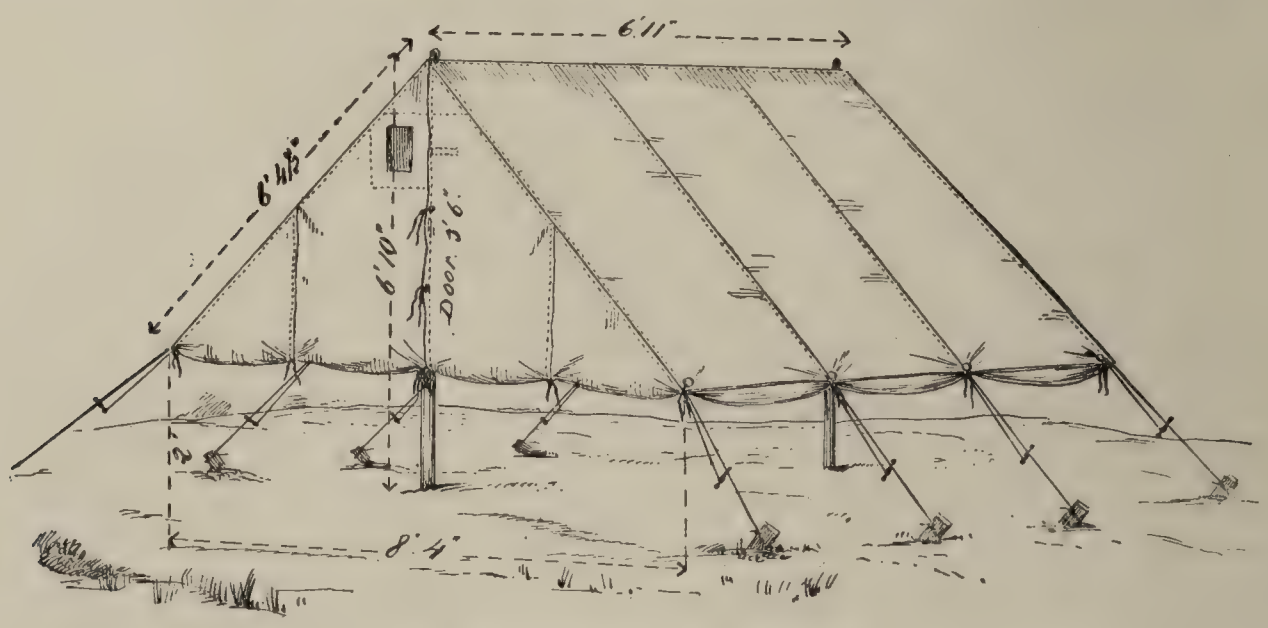


FIG. 141.—Common Tent, New Style.

space to each inmate. A common wall tent with laced corners is also supplied, but has been found to possess no advantages for field service. At present its employment is practically discontinued.

The old conical or Sibley tent, modelled on the lines of the Indian tepee, was used to a large extent during the Civil War, and, although no

longer manufactured, a few are still in existence and utilized by troops. It is 18 feet in diameter, 13 feet high and supported by a central pole upon a tripod; the latter permitting the ready alteration of the tension of the canvas. Ventilation is maintained through a circular opening at the apex, which, in a stormy weather, can be protected by an adjustable hood. This tent has the great disadvantage of possessing no perpendicular wall, and hence much of the sheltered space is not available for use; while the edges cannot be sufficiently raised to admit of the free circulation of air without endangering the stability of the tent itself. Its capacity has been officially prescribed as being seventeen mounted men or twenty infantrymen; giving 12.7 feet of surface and 55 cubic feet of air space to each of the latter.

The conical wall tent, of the pattern approved in 1897, is made of twelve-ounce duck. The roof of the tent is in the form of a frustrum of a cone, 16 feet 5 inches in diameter at the base and 7 inches in diameter at the top. The wall is 3 feet high, and the tent, when pitched, has a height of



FIG. 142.—Conical Wall Tent; Model of 1897.

10 feet. From the top of the wall to the eaves the distance is 10 feet 6 inches. The door has a nominal height of 7 feet, measured along the seam, with a width at the top of $12\frac{1}{2}$ inches and twice that at the bottom. Practically no provision for ventilation is made with this tent, and in this respect it is far inferior to the similar tent, approved in 1888, which has an aperture at the top 18 inches in diameter and is provided with an adjustable hood for use in stormy or cold weather. The old-style tent is excellently ventilated and the air is always sweet and pure, irrespective of the number of occupants. The absence of similar qualities in the new model is an unanswerable argument against its adoption or issue. The conical wall tent is provided with 24 eave lines to permit the wall to be looped up in mild weather. To pitch this tent 24 large and 24 small tent-pins are required. The conical wall tent affords 212 square feet of floor space and 1,450 cubic feet of air space. It is issued in the proportion of one for each twenty foot or seventeen mounted men, but does not fur-

nish comfortable accommodations for more than half that number. Being without a fly it is very hot in warm weather, though less so than the common tent. On the other hand its size, height, and the rapid escape of

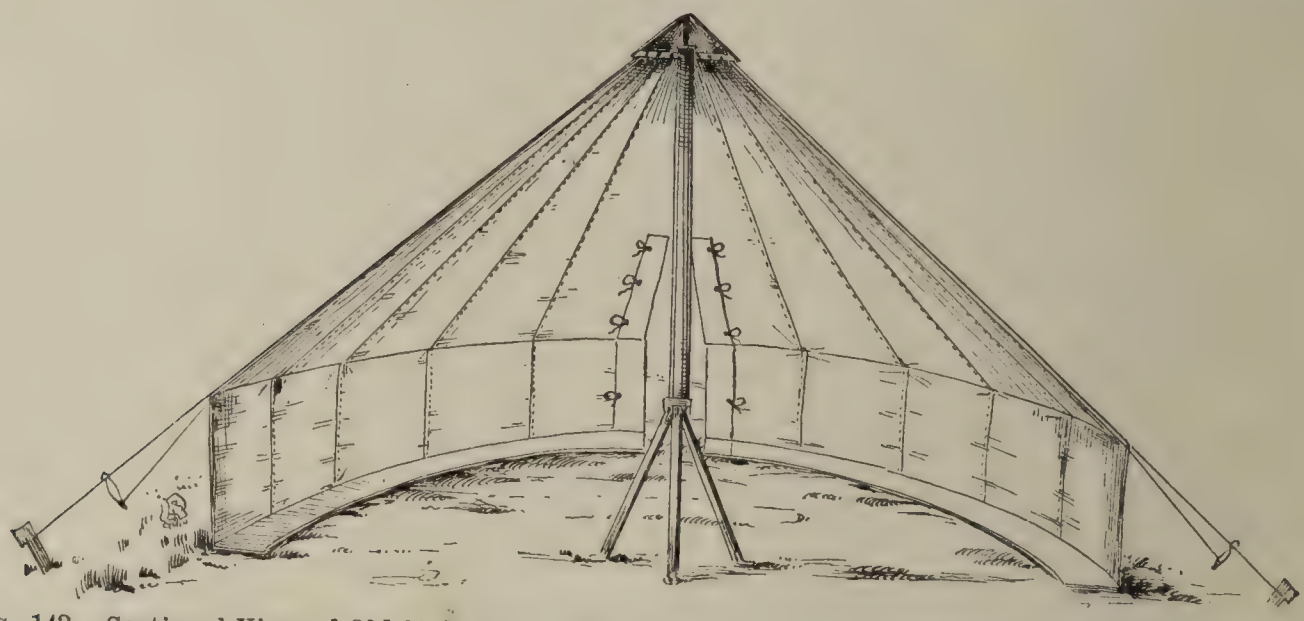


FIG. 143.—Sectional View of Old Style Conical Wall Tent, Showing Adjustable Cap for Apex Ventilation.

heated air through the ventilating opening at the apex render it a difficult matter to keep this tent properly warmed during excessively cold weather. For temperate climates, however, the modified conical tent, model of 1888, appears to be very satisfactory.

The officers' wall tent, made of twelve-ounce duck, has a height of 8 feet 6 inches, a width of 9 feet and a length of ridge of the same amount. The wall has a height of 3 feet 9 inches. The door is 6 feet 8 inches high, and has a width of 12 inches at the bottom and 4 inches at the top. The tent is provided with a sod cloth and is ventilated by apertures 6 inches below the ridge, front and rear, each 4 inches wide and 8 inches long, is provided with a fly 15 feet 6 inches long and 9 feet wide and requires for its erection the use of 10 large and 18 small tent-pins. It has

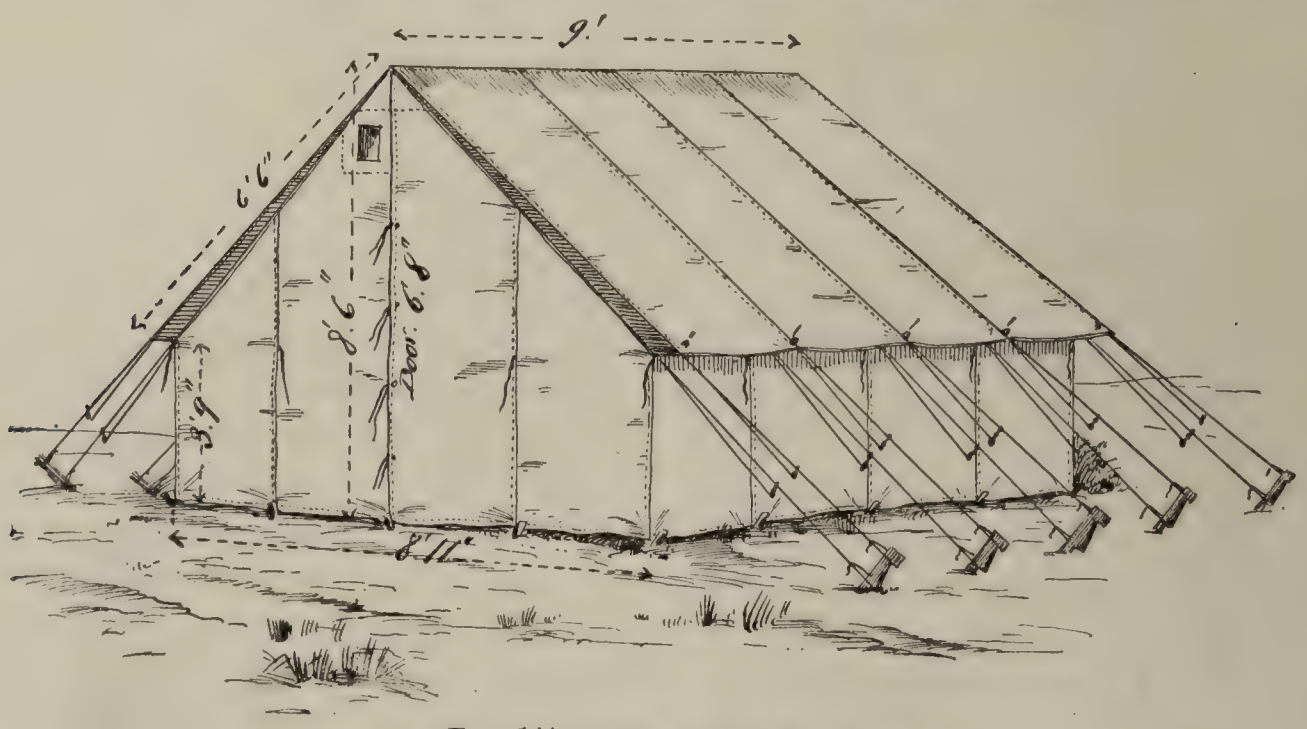


FIG. 144.—Officers' Wall Tent.

81 feet of floor space and 500 cubic feet of air space. The official allowance gives three of these tents to each general officer, two to each field or staff officer, one to each captain and one to each two subalterns; but during

campaign only one wall tent is allowed each general officer below the grade of corps commander, together with one for each two other officers, whatever their rank. This tent is never overcrowded and the question of ventilation requires no serious consideration. Except for the fact that this tent is very hot in warm weather, it appears to be very satisfactory for the use to which it is put.

The hospital tent, made of twelve-ounce cotton duck, has a height of 11 feet, a length of 14 feet and a width of 14 feet 6 inches. The wall has a height of 4 feet 6 inches; while the doors are 8 feet 9 inches in height and have a width of 18 inches at the bottom and 10 inches at the top. The tent is provided with two ventilating apertures, each 5 inches wide and 10 inches long, placed in the front and rear and guarded with inside flaps or curtains. These apertures are located 6 inches from the ridge and 2 inches from the centre of each end. On the inner edge of the wall is a sod-cloth 12 inches in width, which, projecting inward, prevents air currents from entering between the ground and the lower border of the tent wall. The tent is provided with 26 wall-lines for the purpose of looping

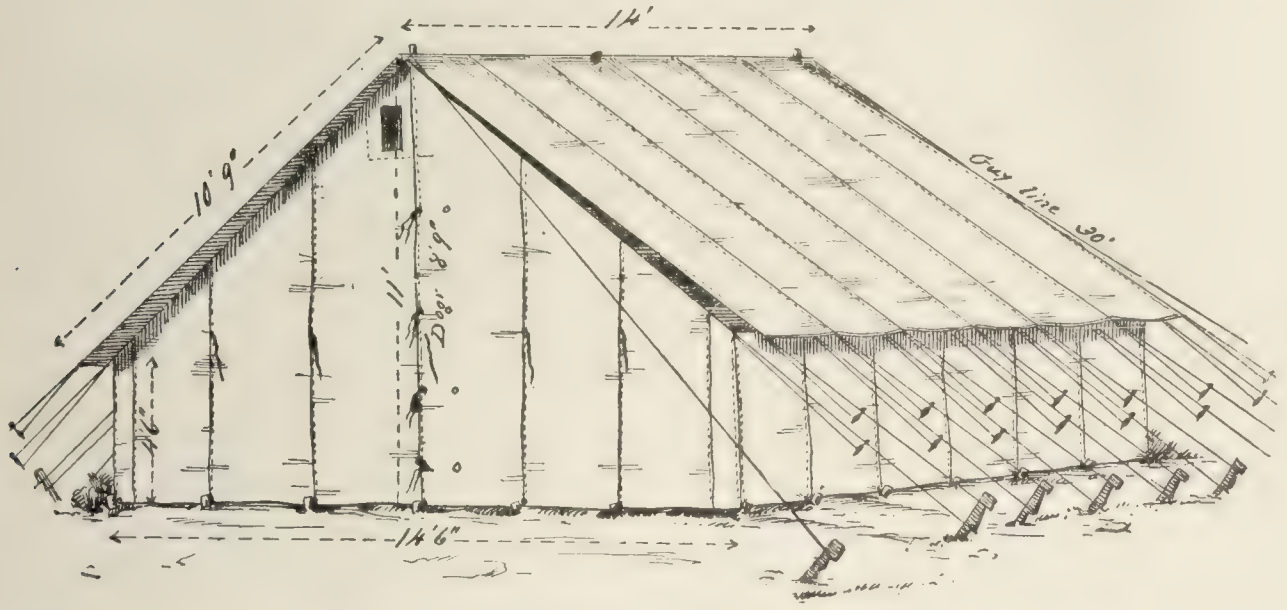


FIG. 145.—Hospital Tent.

up the wall in pleasant weather, while the same number of foot-stops enable the wall to be pegged closely to the ground. The entrances, front and rear, are guarded by broad lapels which can be snugly drawn together by means of four door fastenings and an equal number of grommets. If necessary, each half of the door can be thrown back to expose the interior, while two or more tents can be joined end to end and thrown into a single ward under a continuous covering. When this is done, however, the ventilation is very poor, since the only openings for the renewal of air are in the canvas closing in the ends of the ward. Thus it is apparent that provision for ventilation in a ward of eight or ten tents is no greater than it is in a single tent; and as a result the air becomes so foul that it is generally necessary to loop up the walls, with its accompaniment of glare, flies, dust and outside annoyances. Where a number of tents are thus pitched end to end, entrance and egress of nurses and patients can be had only at the ends of the ward, with great resulting annoyance to the sick in the tents near the extremities, especially if the ward be floored. It is therefore apparent that, where tents of this model are used, the hospital wards should be made as small as possible; preferably being composed of no more

than three or four tent units. The hospital tent is provided with a fly of ten-ounce cotton duck, having a length of 21 feet 6 inches and a width of 14 feet. To properly pitch this tent requires the use of 18 pins 24 inches long and 28 pins 16 inches long.

This tent, originally expected to accommodate eight to ten patients, has had its capacity for many years officially limited to six occupants. Such allowance affords 35 feet of floor space and 233 cubic feet of air space to each inmate; an amount which may be considered as usually sufficient for temperate climates under conditions prevailing in the field.

While the use of the hospital tent for other than hospital purposes has been long forbidden, its employment was found necessary for the shelter of troops in the occupation of Cuba; it proving more suitable for a tropical climate than either the common or conical wall tent. The allowance of six men to each tent was soon reduced to four in the tropics—thus giving each soldier 52 square feet of floor space. The issue of one hospital tent to each corps, division or brigade headquarters has also been recently authorized. For all conditions of field service and varying climate, wherever tentage of such size and character can be employed, the hospital tent has

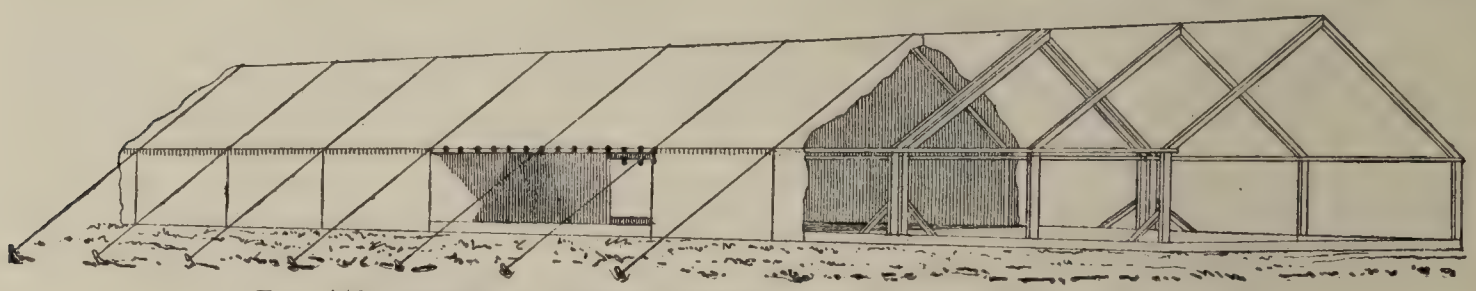


FIG. 146.—Method of Pitching Hospital Tents on Frames to Form a Ward.

been shown by long experience to be a generally useful, convenient and hygienic shelter; being surpassed only by the modification devised by the writer, as described in a subsequent chapter.

In semi-permanent tent hospitals, and where the hospital tent is used for the shelter of troops, the tents are frequently stretched over wooden frames; the guy ropes preferably being tied to a single bar, parallel to each side, in lieu of tent pins. This arrangement gives far greater stability, and at the same time economizes space between tents and facilitates policing of the camp space through absence of the pegs and long guy ropes. It has the serious drawback, however, of converting a movable into a fixed shelter, largely preventing proper sunning and aëration of the tent site and increasing the dangers of soil pollution. It is scarcely a question whether the advantages of the use of frames are not more than counterbalanced by the disadvantages—for men under canvas can be kept healthy only by frequent changes of locality, and where sick are under treatment the rapid pollution of soil is inevitable.

Tentage of Foreign Armies.—This subject, though of great magnitude, can receive only brief notice. The "bell" tent used in the British army has a general appearance similar to that of our conical wall tent, of which it is practically a smaller representative. The base has a diameter of 12 feet 6 inches, while our conical wall tent has a diameter 4 feet greater; but the height of both is the same, 10 feet. The "bell" tent has a ground space of 123 square feet and an air space of 492 cubic feet. It is made of linen canvas or cotton duck, and weighs, all told, about 72

pounds. The "bell" tent is intended to hold from twelve to sixteen men; but this has at times been increased to eighteen or twenty. Ventilation is very imperfectly carried on through a few small protected apertures near the top—there formerly being no provision whatever for such purpose. The English hospital marquee is two-poled, with double canvas. It is somewhat similar in appearance to our own hospital tent, but is much larger. It has a length of 30 feet, breadth of 15 feet, height of sides of 5 feet, height to ridge of 15 feet, a ground area of 385 square feet and an air space of 3,336 cubic feet. This tent is intended to accommodate eight patients and is fairly well provided with facilities for ventilation. Small circular tents, accommodating four patients each, form a recent addition to the hospital equipment. In India the British troops use various kinds of tents; several of these being provided with double flies for greater coolness and protection from the sun.

The French marabout or service tent is also somewhat similar in appearance to our conical wall tent. Its diameter at the base is 6 meters, while its height is 2 meters. It has a capacity of 30 cubic meters and is expected to shelter sixteen men. The French hospital tent in general use consists of an ogival frame, according to Tollet's principle, covered with a double envelope, the outer casing being of linen and the inner of cotton fabric—the latter is rendered non-inflammable by chemical treatment. It is 15 meters long, 5 meters wide and 5 meters high, and is intended to accommodate sixteen men, to each of whom it furnishes 11.5 cubic meters of air space. The "tortoise" tent is also used for field hospitals, this being merely canvas stretched over a wagon, which forms its central support. This tent has very many disadvantages and few merits.

In the German army two kinds of tents are in use. The tent for infantry is a conical wall tent 12 feet high and 15 feet in diameter; providing 70 cubic feet of air space to each of its fifteen occupants. The tent used in the mounted service is wedge-shaped, one end being left open, and much resembles a large shelter-tent. The German hospital tent in $29\frac{1}{2}$ feet long, $24\frac{1}{2}$ feet broad and $13\frac{3}{4}$ feet high. It is divided by curtains into three parts, a central one for sick and two smaller apartments for attendants and supplies. Each tent contains only six patients, though double that number might be accommodated. Tents are rarely used in the German army, and the cantonment system is practiced almost exclusively during manœuvers.

The Russian infantry tent is 14 feet square and 7 feet high to the slope. There is a central pole, with four corner supports. It is intended for fourteen men, but is usually occupied by a less number. The floor space is largely taken up by a bench, $1\frac{1}{2}$ feet broad, around the sides, together with a central rack for rifles. This tent is not intended for use during campaign, when recourse is had to the shelter-tent alone, and is used only in camps of some permanency. In the Spanish army small marquee tents are used by officers; the men using conical tents. The latter are known as Nos. 1, 2 and 3. No. 1 has a height of 3.30 meters, a diameter at base of 6.39 meters and an official capacity of sixteen to twenty-four men. No. 2 is 2.96 meters high, has a diameter of 4.33 meters and accommodates ten to sixteen men. No. 3 has a height of 2.35 meters, a base of 3.12 meters and a capacity of four to eight men. The Austrian infantry tent

is similar to a large old-style shelter-tent, as used in our service. It is wedge-shaped and both ends are left unprotected. It has a height of 4 meters and covers a ground space 7.90 meters long and 6.60 meters wide.

Improvised Huts.—These, during war, afford a means of housing an army expeditiously. For purposes of warmth they are far better than tents for winter quarters, and may also be used during siege, blockade, or when troops are occupying a position which is intended to be held for a considerable period. This method of sheltering troops by huts has been largely developed in our own service, particularly during the Civil War; since, excepting during the Crimean struggle, the adoption of such a means of protection has rarely been found necessary in European armies.

In size, the hut should be small rather than large, since the dangers resulting from soil pollution and the aggregation of large numbers of human beings are thus minimized. During the Crimean War, the huts built by the Allies were sufficiently large to accommodate from twelve to twenty-four men; but four men, where possible, should form the unit of occupancy. Should large huts be employed, the accommodation may be calculated on the basis of not less than two running feet to each inmate, where only a single row of beds is intended. In the Spanish army the following proportions are officially required to be maintained in the construction of improvised huts:

Number of men.	Length, interior, meters.	Width, interior, meters.	Height, meters.	Number of men.	Length, interior, meters.	Width, interior, meters.	Height, meters.
8.....	5.20	2.70	2.80	16.....	5.20	4.75	3.50
10.....	6.50	2.70	2.80	18.....	5.85	4.75	4.00
12.....	3.90	4.65	3.00	20.....	6.50	4.75	4.00
14.....	4.55	4.65	3.50				

Huts should be separated by intervals considerably greater than is necessary in the case of tents; since the amount of soil pollution is dependent upon density of population as well as duration of occupancy—and a change of site, so readily accomplished with the use of tentage, is not possible

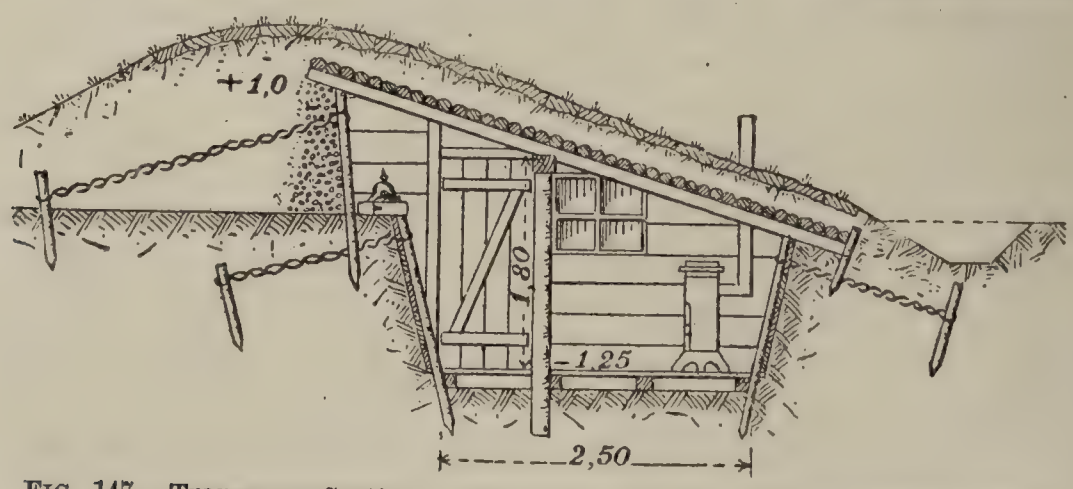


FIG. 147.—Transverse Section of Excavated Hut Used in the German Army.

where fixed shelters are employed. Efforts to separate huts widely will usually be opposed by the desire of the commanding officer to possess a compact camp for convenience in handling his men; but huts should never be located nearer to each other than a distance equal to one and one-

half times the height of the ridge. For all permanent camps or winter quarters, huts are best arranged in echelon.

Underground habitations are warm, but are usually damp and always difficult of ventilation, and hence should never be employed where other protection is available. Even the banking of the sides of a surface hut

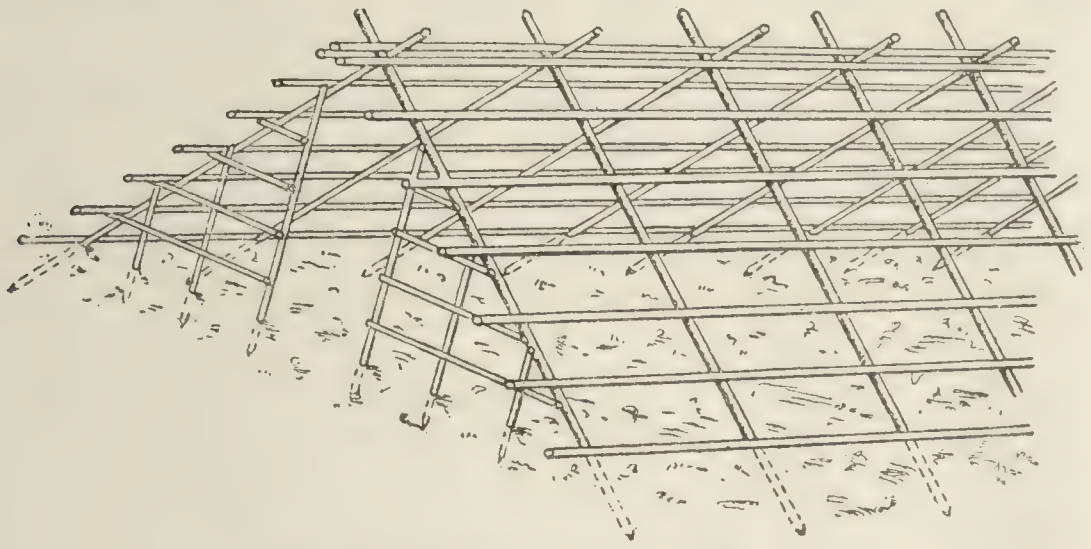


FIG. 148.—Frame for Thatched Hut.

should be avoided. In the British and German armies, however, many of the forms of winter huts recommended are wholly or partially below the surface of the ground, and excavation by the soldier is still officially encouraged.

The materials of which improvised huts are made must necessarily vary according to the resources of the locality, and are usually brushwood, logs, straw, reeds, clay, turf or stones. The size of such habitations depends upon the material available for their construction as well as the number of men which they are intended to shelter; but, as already stated, the unit of occupancy should be small. Huts for warm climates may be built by simply erecting a framework with skeleton roof; the latter being thatched with straw, reeds or other suitable material. Bark of trees, detached in large strips by beating with a flat piece of wood, is excellent for the construction of walls and roofing. Bamboo has been much used in the British service for the construction of temporary shelters, and its employment for this purpose has given excellent satisfaction, notably in the Ashantee and Suakin expeditions and on the northeast frontier of India. In the several campaigns in the Soudan, huts were largely constructed of sun-baked bricks, their use giving excellent results; but like the adobe huts, much used in our own southwest, they are leaky and damp in anything but a rainless climate. According to Smart, one camp in Arizona, in existence for ten years, consisted of merely shelter-tent roofing over walls of willow-work, with a canopy of brushwood erected over the whole to afford a better shade.

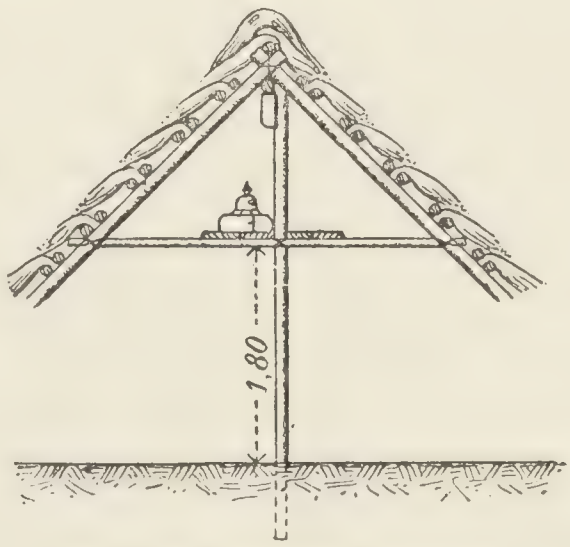


FIG. 149.—Method of Thatching.

In dry and moderate climates the walls of huts may be constructed of poles planted in the ground, or closely woven wicker-work daubed over

with clay containing a small proportion of some fibrous substance—as straw, grass or horsehair—chopped into short lengths to prevent the clay from cracking and opening as it dries. This mixture, of the consistency of thick paste, should be worked in with the hands. In the Crimean War the so-called "dug-out" was largely employed as winter quarters for troops; and the same shelter is still used to some extent by settlers in the prairie states of the northwest, where timber is scarce. Sods, used like bricks, make an extremely warm and comfortable habitation—but one which is scarcely adapted to general military purposes. Like the adobe hut, the sod house is valuable only for dry climates, and is both uncomfortable and unhealthful during prolonged wet weather. Where such material is available, the walls may be constructed of stone, either laid in mortar or chinked with mud alone.

When timber is abundant, log huts will preferably be constructed; and these, well chinked and plastered with mud or mortar, make comfortable shelters in cold weather. They were much used for winter quarters during the Civil War. Such huts, however, unless roofed with canvas, are

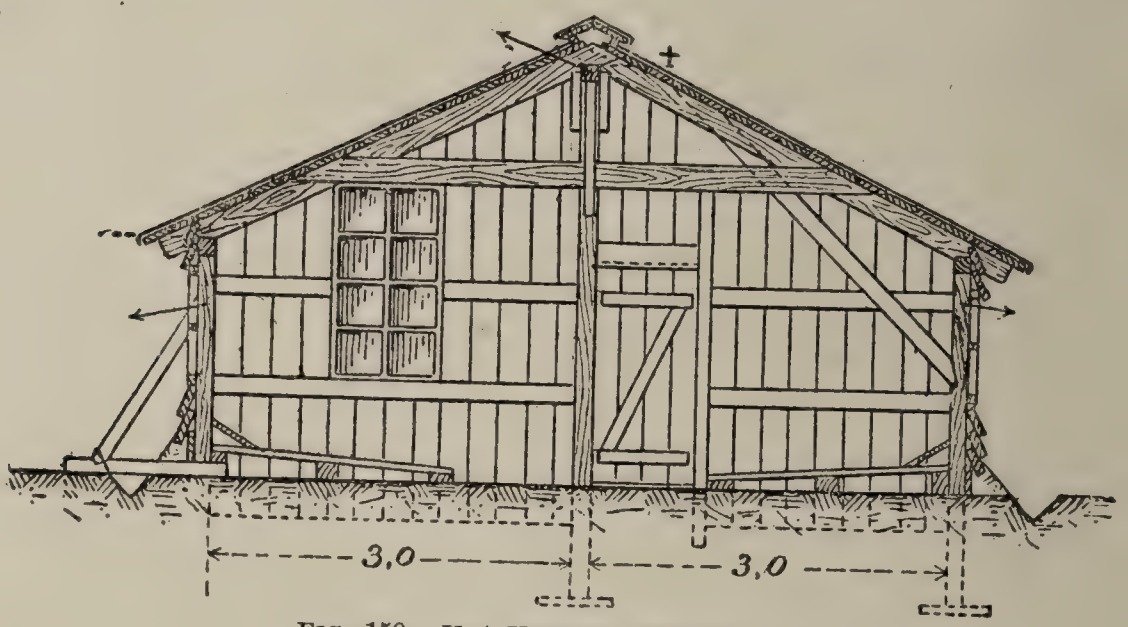


FIG. 150.—Hut Used in German Army.

usually insufficiently lighted, since windows are difficult to obtain or devise. Log huts should not be less than six feet under the eaves and should afford as much space to the hut squad of four men as the means at hand allow. Without a sound roof, walls are of little value. During the Civil War shelter-tents furnished the available roofing material; but the best arrangement for roofing, as suggested by Smart, consists in the employment of a piece of canvas 12 x 14 feet, with a slightly larger piece for use as a fly; this giving a hut having six-foot walls a capacity of 700 cubic feet, and permiting the free circulation of air through ventilators cut in the roofing canvas. It is important that the canvas should be so fixed to the walls as to permit of its ready removal for the admission of sunlight. If the flooring be of earth, a little of the surface dirt may from time to time be removed and replaced by gravel or wood ashes; the latter, when well pounded, making an excellent floor. If sawn lumber be used for this purpose and the climate be not too cold, the floor should be so elevated as to permit the free access of air between it and the ground—the boards being loose, or held in place by screws rather than nails, to admit of their removal for the cleansing of the subjacent space.

In the Crimean War, where various prepared huts were employed, a strong opinion existed among the British troops that the men would have done better had they been supplied with raw materials and permitted to hut themselves. In general, it may be considered that the nearer the hut approaches a well-built barrack the greater its superiority over the tent—but a hut may be so constructed and occupied as to render its use inferior to that of canvas.

The following remarks on the erection of winter huts have been made by Smith: "In their construction a space should be cleared for about three feet around the proposed site. The ground to be included within the walls should be smoothed and slightly raised, never excavated, and should be pounded or hardened. Trenches should be dug around the hut and thence in a direction and to the distance required for effective drainage. The ground outside may be slightly raised, but an embankment should never be erected around the bottom for the sake of warmth; but instead

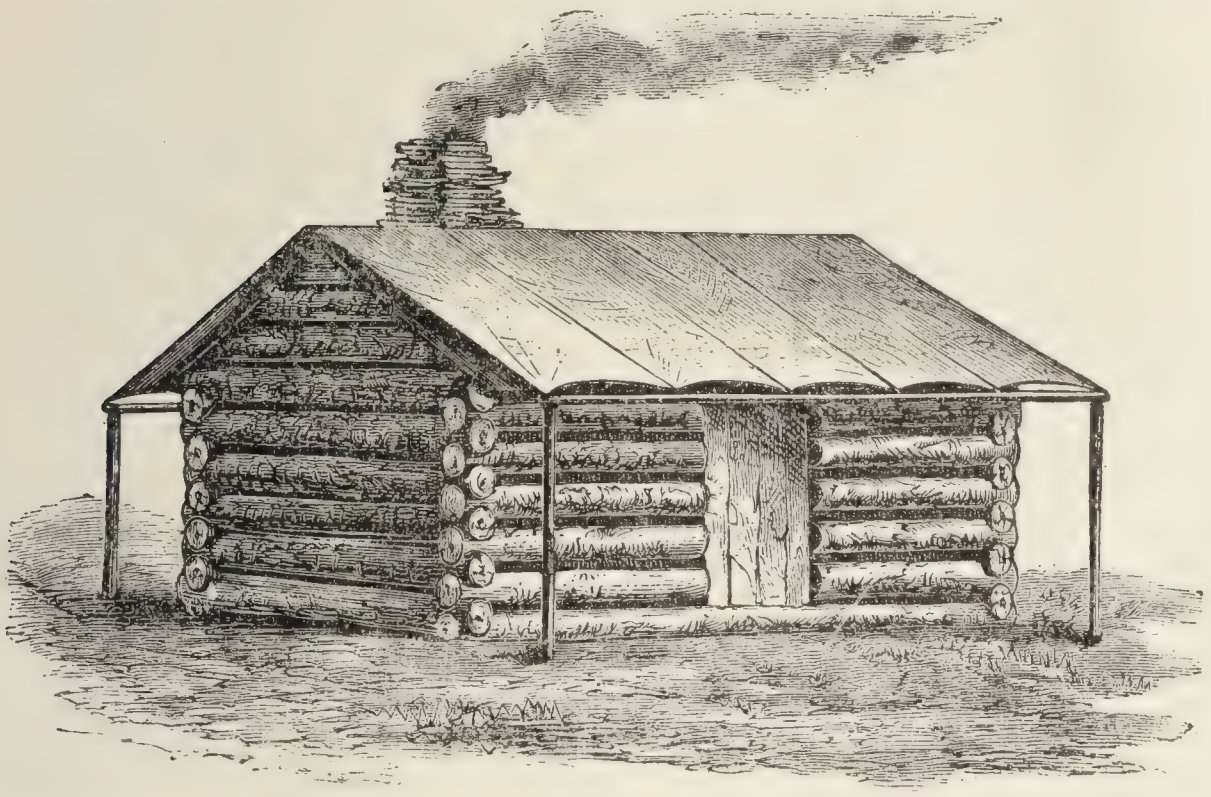


FIG. 151.—Log Hut for Four Men. (After Smart.)

the hut may be lined to a convenient height within, to ward off currents of cold air. The cleared space outside should be paved or covered with gravel. Wooden floors should be laid, if possible, and suitable provision made for the entrance of the air from the outside through either the floors or the lower part of the walls. Eaves should carry the rain some distance from the walls, and, if possible, porches should be built, as adding much to the comfort of the inhabitants. Ventilation should be secured at ridge, end and sides."

The great fault of extemporized huts, in cold countries, is that ventilation is apt to be sacrificed by the soldier in the maintenance of warmth. Further, shifting of the site is impracticable, and a ground area, once contaminated, cannot be abandoned without the expenditure of considerable labor. For this latter reason troops should be promptly removed from winter quarters on the advent of warm weather.

Recourse to extemporized huts, built by the men themselves out of such rough materials as may be at hand, will perhaps be required in future

military operations beyond the seas, but can scarcely be necessary for large bodies of men within the present limits of the United States. The resources of this country are so vast, and railroad facilities are so excellent,

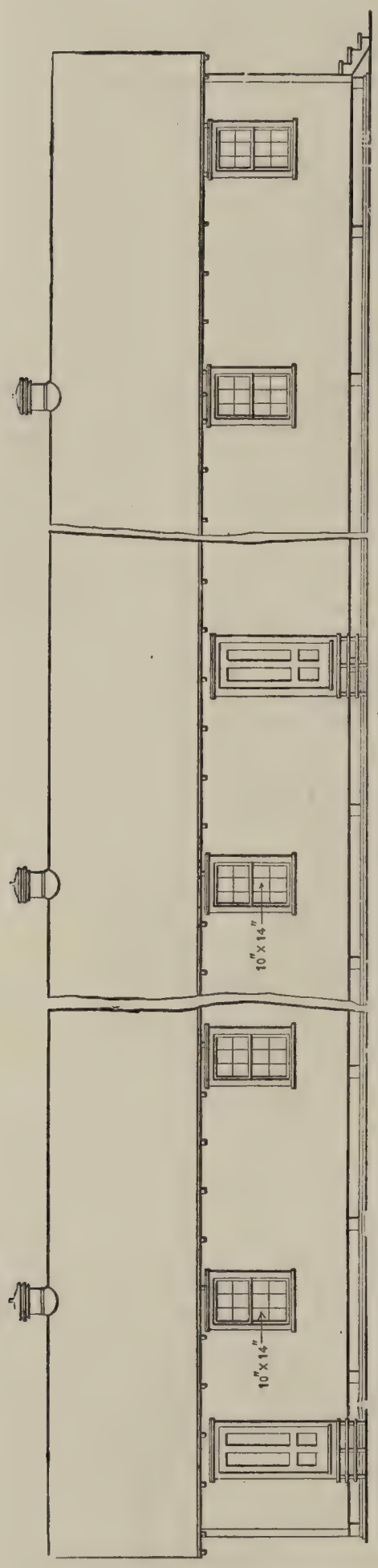


FIG. 152.—Side View of Frame Barracks, Erected as Winter Quarters During the War with Spain.

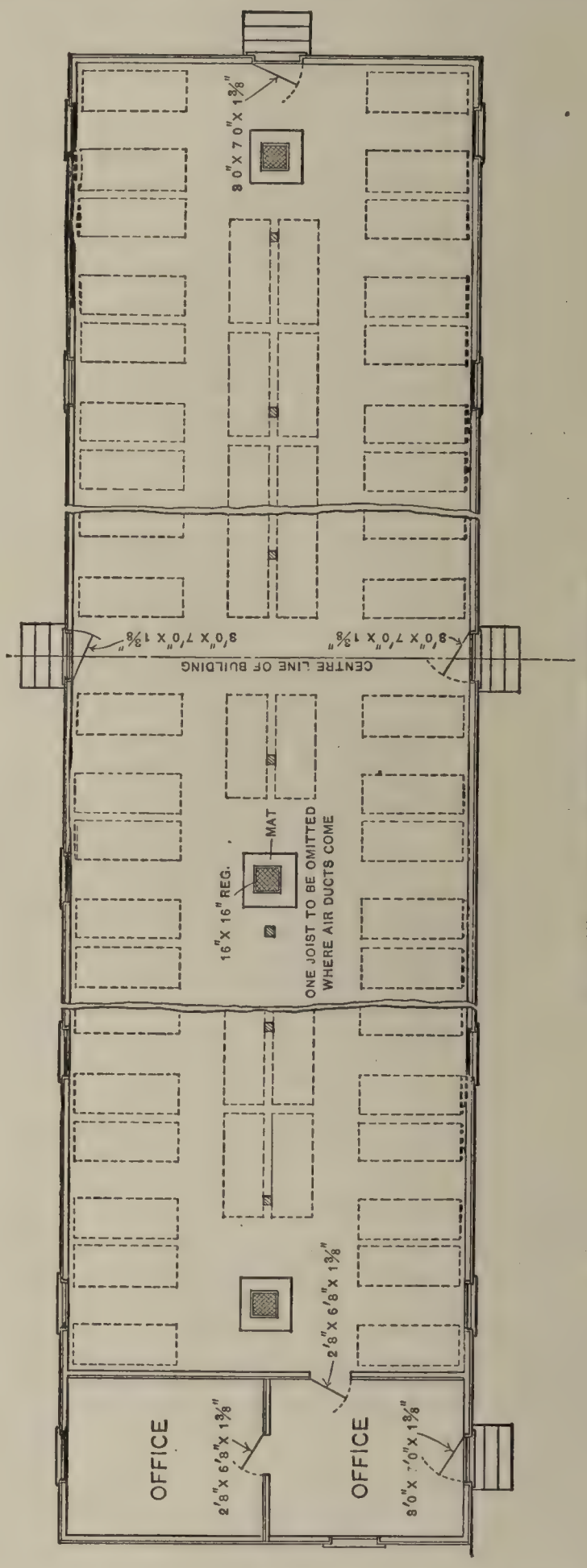


FIG. 153.—Plan of Same Frame Barrack.

that for winter quarters or where canvas shelter is deemed insufficient or too expensive, it is probable that sawn lumber for the erection of rough but hygienically constructed frame barracks, far more comfortable and suitable for the use of troops, will always be supplied.

Frame Quarters.—In 1898, the troops encamped in the southern states were quartered for the winter in temporary frame buildings, erected

by civilians under contract. These buildings were raised above the ground by heavy posts resting upon mud-sills, and were closed in with $\frac{7}{8}$-inch smoothed yellow pine boards, laid horizontally. The roofs and outside were covered with water-proof sheathing paper, the boarding extending down to the grade line. The windows were fitted with sliding sashes, ex-

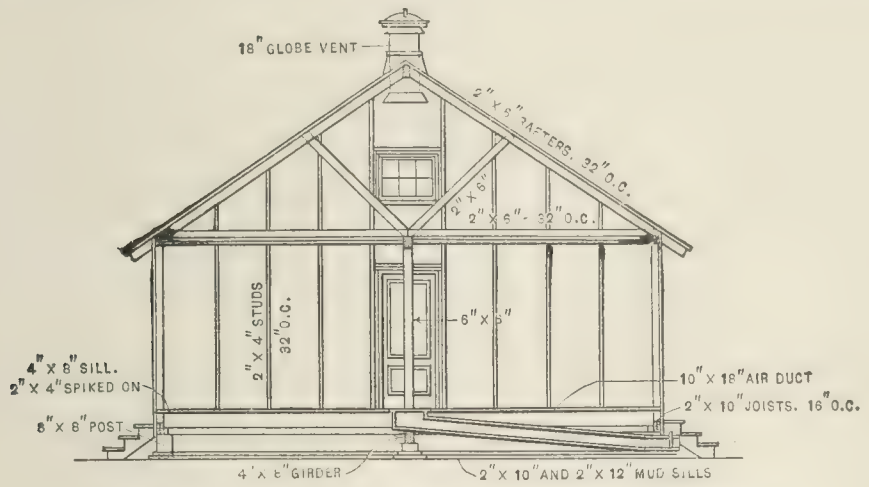


FIG. 154.—Sectional View of Same Frame Barrack.

cept those in the gable ends, which were pivoted and provided with cords and pulls to enable their manipulation from the floor. Air ducts, 10 x 18 inches, extended from one foot outside each building to under each stove —each air duct having a regulating damper—where they were finished with registers 16 inches in diameter. Each building was provided with three 18-inch ventilating outlets and with two doors on each side. Each barrack building was 112 feet long and 26 feet wide, and was intended for the accommodation of 64 men, besides containing two office rooms at one end. Such a frame barrack was inexpensive, spacious, comfortable and fairly well ventilated, and served admirably for the purpose for which it was intended. It would scarcely have been warm enough for use in a rigorous climate, however, unless built with double walls; while the erection by the men themselves of such an elaborate structure would scarcely have been

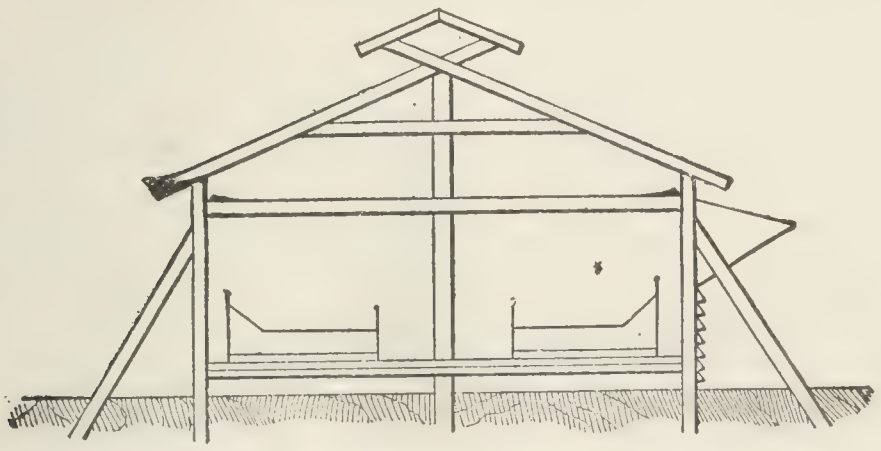


FIG. 155.—Frame Barrack Used in the German Army. Showing ridge ventilation.

possible. Buildings erected for troops and buildings erected by troops are necessarily quite different in character.

Frame shelters similar to the above are much used abroad in the permanent camps of instruction, but are occupied by troops only during the annual manœuvers. Used in this manner they give entire satisfaction; but where they have been permanently occupied, outbreaks of epidemic diseases seem to have invariably resulted. In the English service it has

been recommended that temporary shelters be sufficient to hold each twenty-eight men. The length suggested is 32 feet; breadth 16 feet; height to ridge 16 feet. Such a building affords 400 cubic feet of air space per man. Two such huts are to be placed end to end, with a single chimney between them—a petty economy not at all advisable, since such large structures should always be separated from each other by a distance equal to at least twice the height of the ridge.

In warm climates, where troops are quartered in temporary frame barracks the roofing material is of the greatest importance. Metallic roofing renders buildings extremely hot; a fact unfortunately disregarded in the construction of our temporary barracks in Cuba, where corrugated iron was employed. Probably the best available material for such purposes, everything considered, is tarred paper.

A convenient arrangement for winter quarters in a not too rigorous climate, combining the use of both tents and huts, was devised by Falk

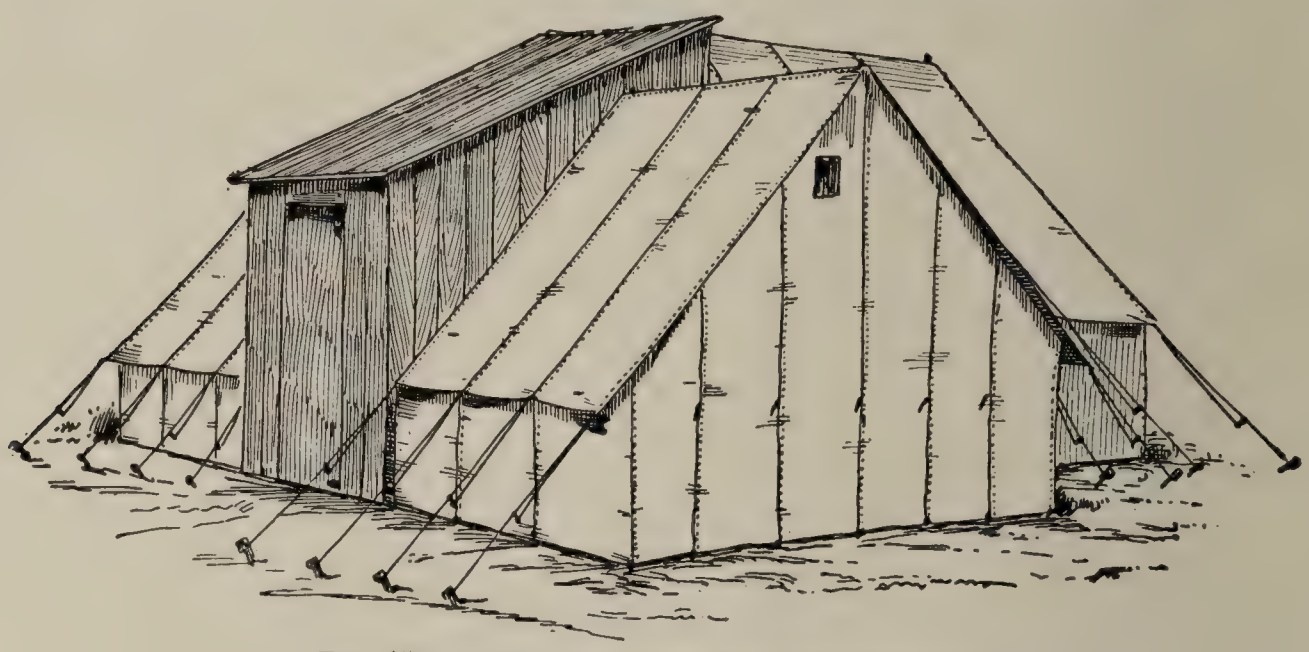


FIG. 156.—Falk's Arrangement for Winter Camps.

and put into practice in the camp at Anniston, in 1898. In this plan the common wall tents in use were pitched in groups of three; radiating from a central frame wooden cabin having a length and width of 8 feet 4 inches, or equal to the width of the tent. This building was provided with four doorways; three leading into the adjacent tents and closed by their canvas flaps, while the fourth opened into the company street and possessed a frame door. The central structure contained the stove and rifle racks, and afforded a comfortable lounging place for the men. This system effected a great saving in stoves, fuel and tentage; the central cabins being erected at a cost of less than $3.00 each. Ventilation was said to have been good, while the tents, used only for sleeping purposes, could at all times be aired and their floors raised for the ventilation and cleanliness of the tent site. The only objection to the arrangement is one which applies as well to all fixed camps—the location could not be changed without implying the destruction of the cabin itself.

Portable Barracks.—Portable barracks, of which there are numerous varieties, are usually made of wooden or metallic frames covered with a special kind of felt protected by canvas. These buildings are all well ventilated by windows, flues, cross louvres and ridge ventilation, and, as a re-

sult of careful investigation into their merits, the use of one or another model has been authorized in nearly every European service.

The Ducker portable barrack, made in the United States, has a frontage of 17 feet and a depth of 33 feet. There are also front and rear annexes, 3 x 5.5 feet, used respectively for vestibule and toilet purposes. The building is constructed of double sections hinged together, each enclosing a cot, table and stool, and is set up by a locking device without the use of screws, nails or external appliances. Expert help is not required for its erection, and it is said that two or three men can prepare such a barrack for occupancy in three or four hours. Each section weighs about 50 pounds, and the whole building, when packed, occupies a space of about 900 cubic feet and weighs 2,500 pounds. The material employed in the construction consists of wood frames with panels of patent fiber board, protected on the outside with 8-ounce duck cemented to the panels. If desired, a canvas roof with fly may replace or screen the sectional roof.

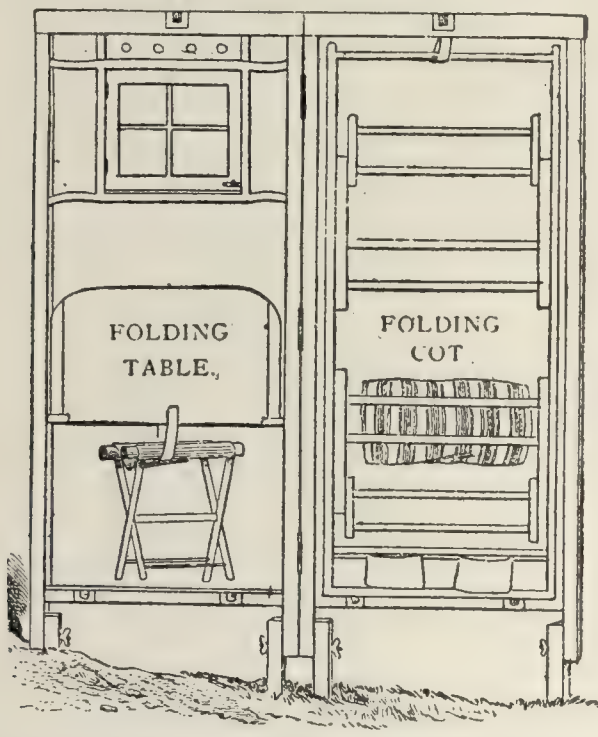


FIG. 157.—Section of Ducker Portable Barrack, Open.

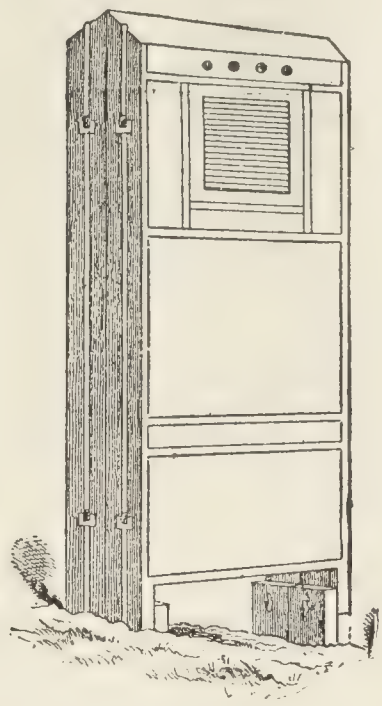


FIG. 158.—Section of Ducker Barrack, Closed for Transportation.

The building is excellently ventilated, possesses double walls to modify extremes of temperature, and allows 56 square feet of floor space to each of the ten occupants which it is planned to accommodate.

The Doecker barrack is but little different in its essentials from the preceding. It is made in Denmark, and has been adopted for use in the armies of England, France, Germany, Austria, Denmark and Sweden—nearly every service requiring various changes in the original model better to suit local conditions. The type of the Doecker barrack used in the French army is 15 meters long, 5 meters wide and 5 meters high. It is intended for 16 occupants, to each of which it gives 17 cubic meters (600 cubic feet) of air space. When packed, the building weighs 3,600 kilos (7,900 lbs.) and requires for its erection the labor of six men for one day. According to Laveran, one such barrack building can be carried in a single large wagon.

The Berthon portable barracks are highly commended by Notter and Firth. This pattern has not, however, been adopted for use in the military service of any nation, and it is difficult to see exactly where its special

applicability to military conditions lies. The expense of this barrack is considerable. Portable buildings have also been invented by Tollet, Espitalier, Olive and others.

While excellent service can undoubtedly be rendered by portable barracks under certain limited conditions, their value for the military service should not be highly estimated. It is evidently impossible, even under the best of circumstances, to house in this manner a large number of troops, even if first cost and comparative lack of durability did not interdict such action; while in time of war their transportation in sufficient quantities would evidently become impossible. Frame barracks, well constructed, are relatively inexpensive and are larger and more comfortable than portable barracks, and their erection is not a matter of great time or labor. Moreover, the latter cannot long withstand rough handling or being repeatedly put together and taken apart. Portable buildings, in the military service, would probably be of the greatest value in connection with



FIG. 159.—External View of Ducker Portable Barrack.

base hospitals, or during epidemics when hospital accommodations are insufficient. They might also be of advantage for purposes of isolation, in connection with outbreaks of contagious disease during very cold weather.

Permanent Camps of Instruction.—Nearly all the larger armies of the world maintain permanent camps of instruction, which are used by troops only during certain periods of the year, usually in the autumn. In the majority of these camps the troops occupy rough wooden buildings, and there is usually a system of sewerage and a piped water supply. In the British service, permanent camps of instruction are maintained at Aldershot and the Curragh; the barracks being light frame structures with double walls and capable of accommodating twenty-five men each. In the French service, a summer camp was maintained at Boulogne from 1803 to 1856, at which time it was transferred to Chalons, where a large number of frame pavilion barracks have been erected. Until recently the German army possessed no special places or facilities for encampment during the fall manœuvers, the troops heretofore being billeted on the civil population. Recently, however, a temporary camp has been constructed at Boeberitz capable of sheltering 6,000 men. The Russian army goes into camp for

instruction each summer at Moscow, Krasnöe-Selo and Varsovie—the troops living partially in frame barracks and partly under canvas. Italy maintains temporary camps of instruction at Fojano, San Morizio and other places; and fixed encampments of this character are also maintained by Belgium and Denmark.

Permanent camps of instruction have not been established in the past in our army, by reason of the small number of men composing the latter, and their dissemination over so wide an area as to render their annual concentration not only difficult but costly of accomplishment. It was also supposed that the practice march required to be performed each year by troops would give sufficient instruction in field service. Recently, however, the necessity of having our officers familiar with the management of large bodies of troops has been emphasized, and the establishment of a permanent camp at some central point—as the Chickamauga National Park—has been strongly urged. If this be done, the location of the camp should be carefully selected, and drained, sewered and piped as if for a post. Rough but substantial buildings should be erected, suitable for warm weather, and facilities provided for the disposal of excreta and refuse by the most approved methods. Should these precautions be neglected, annual outbreaks of enteric fever and other infectious diseases may be expected to occur among the troops under instruction.

CHAPTER VIII.

THE SANITARY ADMINISTRATION OF THE CAMP.

The Camp Space.—In the establishment of the camp, troops should never pass over or form upon ground which is to be occupied by tents, since it is most important that this space should be kept clean and the turf unbroken. Baggage wagons, also, should be carefully driven in the intervals and not over the intended tent sites; not alone for the same reason, but also because fouling of the ground by horse urine and droppings is liable to occur while the camp equipment is being unloaded. After the camp has been established, no traffic of any kind should be allowed along its front or through the company streets, so as to limit the production of dust or mire as far as possible.

The outlining of a general plan for grading and trenching a camp of any permanency should follow its location; the details being subject to modification as a result of careful inspection of the camp area on the first rainy day, when the natural trend of the surface water can be accurately determined. The work itself may be gradually done after more pressing duties have received attention. The drainage should preferably be toward the flank, away from the tents and kitchens. In permanent camps or winter quarters the trenches for the removal of storm water from the vicinity of the tents may be advantageously paved with pebbles. All surface drainage from higher ground should be carefully intercepted and turned aside, and in camps of any permanency such depressions as are liable to retain water should be either filled up or drained.

A hut or tent, even in presumably temporary encampments, is not ready for occupancy until protected against invasion by storm water. For this purpose, with hospital or officers' tents, a trench having a width and depth of four or five inches is dug close to the wall in front and rear, and about four inches from the sides on each flank, corresponding to the lateral edges of the fly, banking the earth slightly so that no overflow can reach the interior. With the conical wall tent, the trench closely follows the canvas where it meets the ground. Such a trench, to be of value, requires an outlet; and this should lead into a main trench or gutter of a size sufficient for the ready conduction of the rainfall from the company area.

Within the limits of standing camps the construction of roads will frequently be required, and this possible necessity should receive due consideration in the selection of the camp site. Pathways should be constructed along the company streets—and these, together with those communicating with the sinks and kitchens, should be so graded, drained or gravelled as to enable the men to avoid mud and water while in the performance of their routine duties. In many instances, elevated plank walks can be constructed; or, in a wooded country, split logs may be used for a similar purpose. Where the soil is soft and an abundance of gravel

can be procured, it is well to place a thin dressing of the latter material over a portion of the company street, and thus ensure a hard, dry area upon which the men can assemble in wet weather.

In the temporary camps of mounted troops the position of the picket line is a matter of regulations; but in standing encampments of large cavalry commands the animals should preferably be located at a convenient distance outside the limits of the camp proper. The picket line should be carefully policed, particularly in warm weather, since flies find in horse droppings not only a food but a favorite medium upon which to deposit their eggs.

Camps which are occupied for a short time only are generally healthful. This, however, is not the case if troops remain on the same site for several weeks or months; and the sanitary officer should be fully alive to the necessity of fresh soil for tents, particularly with raw troops and a large command. In the French campaigns in Tunis it was often noted that the troops which remained longest in fixed camps furnished the largest proportion of sick—and experience has amply demonstrated that a camp which is not moved will ultimately become seriously infected. On the other hand, the evacuation of an infected site is of powerful assistance in bringing epidemics to an end. Gordon recommends that camp sites be changed every eight days; while Baudens considered that tents should never remain on the same site more than half that time, and in the German army, troops are not allowed to bivouac on the same spot more than twenty-four hours; but the period during which a camp may be safely maintained on the same site is a matter which must evidently be largely regulated by circumstances. Whenever troops are under canvas, however, unless some military reason other than expense or inconvenience prevent, it is always desirable that camps should be moved at intervals of a week or ten days to a distance at least sufficient to clear the confines of the old encampment, without waiting until a general infection of the camp or soil has obviously been accomplished. It does not suffice merely to strike tents, though this, especially in sunny weather, is of much advantage—the camp site itself must be abandoned.

Habitations.—Grass in the tent area should always be cut short, or, in camps of a more permanent nature, pulled up by the roots. Under any circumstances, such grass is soon killed, and by its decomposition adds to the contamination of the tent atmosphere. The ground composing the floor of the tent should be well pounded to render it less permeable, and where wood ashes are available they are sometimes used as a top dressing. In the German army, if the soil be not considered of desirable character, the tent area is excavated to the depth of one foot, and the dirt so removed is replaced by gravel or ashes and watered and pounded until hard. In all camps of any permanency the flooring of the habitations conduces much to the comfort and cleanliness of troops. Such flooring, usually of planks, should be in sections of convenient size to permit of its removal for purposes of cleanliness and aëration, and should be raised several inches from the ground by the use of scantling or split logs. In the French army, cement floors have been used in the tents of standing camps and have been favorably reported upon. The ground included in the tent area is slightly excavated, the excavation filled with broken stone and the

whole covered with a layer of cement. Earth should never be removed from the inside of tents or huts with a view of increasing space, since such an excavation is nearly always damp and the occupants are more exposed to emanations from the soil. The danger of excavating the enclosed area was well shown in the Crimean War, when the troops were allowed to take such action in housing themselves; the sickness and death rate among troops occupying such shelters, notably the 79th Highlanders, being far greater than among troops living under other conditions. Soldiers should always sleep above rather than below the surface of the ground.

A certain amount of fresh air may filter its way through dry canvas; but if the latter becomes wet, through rain or dew, the fiber swells to a considerable extent and the texture becomes practically impermeable. Hence no reliance should be placed upon renewing the air of the interior of the tent by any means except the use of ventilating apertures, properly located and of sufficient size. With the exception of the latest model conical wall tent our tentage may be considered to be fairly well aired as military tents go; although with the former allowance of inmates for the common tent the atmosphere was frequently confined and disagreeable odors were marked. The excellent ventilation of the 1888 pattern of conical wall tent keeps the air constantly sweet and pure, no matter how large the number of occupants; and the same is true of the tent devised by the writer, in which ventilation is so free that the inmates are practically in the open air. With even the best kind of tentage, however, except the pattern last mentioned, on account of the small allowance of air space afforded the men, the tent door is best left open except during wintry or inclement weather. The walls of tents should also be kept raised as much as possible; and even at night the leeward side may often be looped up with advantage. In moderate weather the ventilation of tents is usually fairly free, but in winter the effort at the maintenance of warmth implies an attempt at the diminution of ventilation on the part of the soldier. In extremely hot weather, hospital or officers' wall tents may be better ventilated by slitting up a seam in the roof near the ridge, inserting a notched stick to keep the opening well spread, and thus permitting the efflux of heated air between the tent roof and the fly. Tents should never be banked up with earth for the sake of warmth, nor should the sod-cloth be covered with earth for the better exclusion of air currents. Clean, smooth stones may be used for the latter purpose if anything be necessary, but no more compact material should be allowed.

In the bivouac, or where shelter tents are used, open fires afford the only means of obtaining warmth. If kindled a few feet in front of the tent the interior is usually comfortably warmed, but if a strong wind is blowing such fires must be carefully located and watched. Fires built for heating purposes should not be too large. If small they are more readily controlled as well as being much more economical of fuel, and if properly tended they radiate an ample amount of heat. The camp-fire is best built in Indian fashion, one end only of each stick being ignited and the pieces of wood being disposed like the spokes of a wheel. By pulling out or pushing in the fuel toward the centre, the fire may readily be made to die down or burn up more freely. With the conical wall tent, pattern of

1888, a small fire of this character may be kindled, in the absence of stoves, in the centre of the floor space, the smoke finding its way out through the ventilating aperture at the apex.

The so-called California stove consists of an excavated fire-place in front of the tent, with a flue covered with earth and sod running under the tent floor and connecting with a chimney in the rear. The hot air and smoke are drafted through and warm the tent—but it is difficult in practice to prevent vitiation of the air in the tent by smoke and gases, and accidents from fire are naturally somewhat frequent.

In stormy or very cold weather, tents are best heated by the use of the Sibley stove. This has the form of the frustrum of a cone and is made of malleable sheet iron. It has a height of 28 inches, a bottom circumference of 58 inches and a weight of about 19 lbs. Draft is provided by

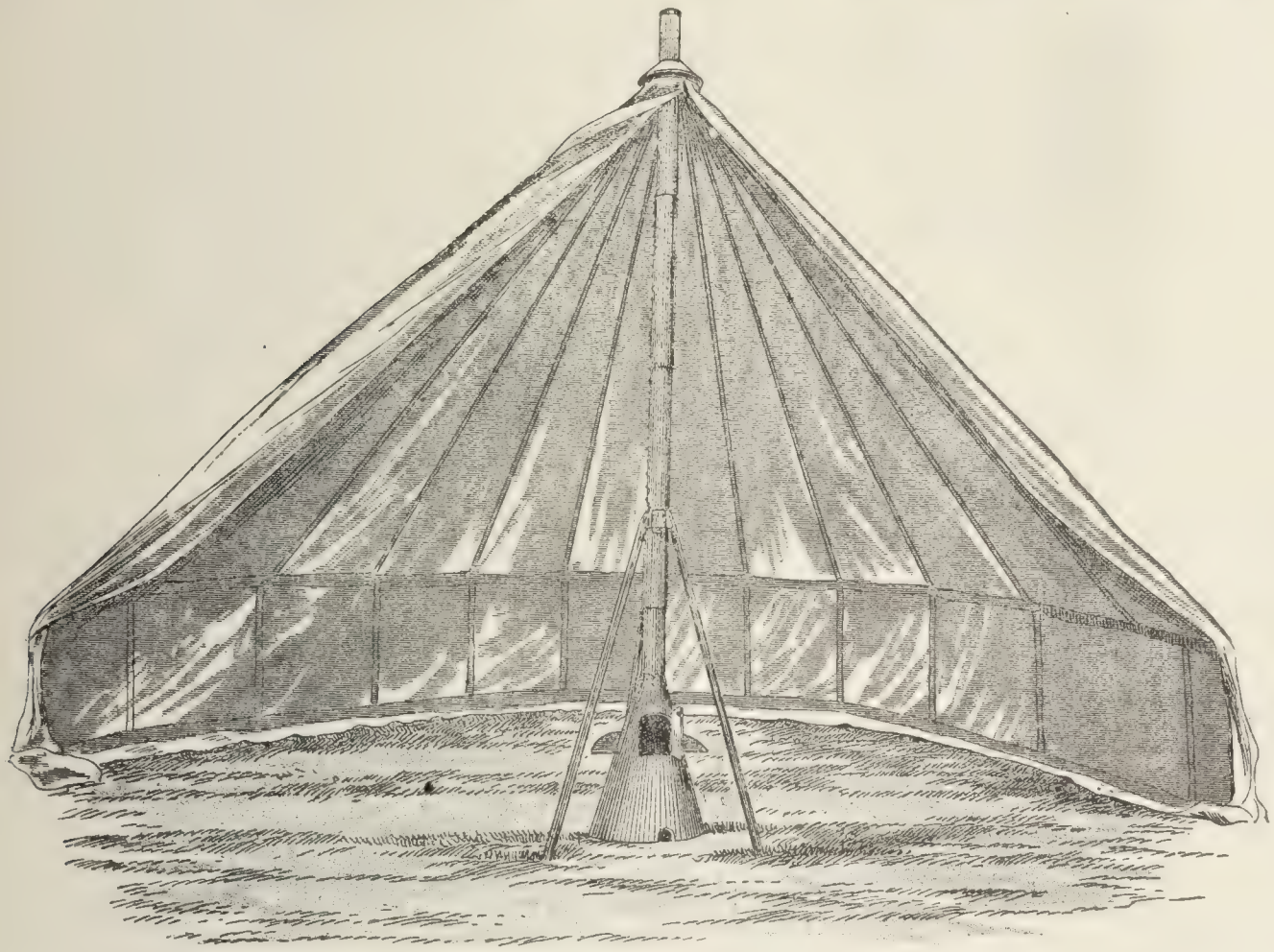


FIG. 160.—Arrangement of Stove and Chimney in New Model Conical Wall Tent.

a triangular shaped vent at the bottom. Recent models of this stove are equipped with a spark arrester and cup shelf. This stove is capable of burning either wood or coal, while its small size and the small amount of iron used in its construction enable it to be rapidly cooled for removal and packing on breaking camp. It is a rapid and powerful heater, particularly where resinous or very dry wood is employed; and hence the tent is usually overheated by the inexperienced through the use of too much fuel. As combustion of the fuel is rapid, such a fire requires constant replenishing for its maintenance. Usually the fire is ultimately permitted to die out during the night, except in the coldest weather, when the previously overheated occupants of the tent are liable to become chilled. While this stove is particularly adapted for use in the conical wall tent, the hospital or other tents may be heated by its use—the pipe being bent in a double right angle and conducted outside the tent through a ventilating aperture.

Some tents have a hole punched through the roof, sufficiently large to admit the passage of the stove pipe and lined with asbestos cloth, tin or zinc to prevent accidental conflagration through an over-heated stove pipe. When in use one corner of the tent fly is tied back so as to uncover the aperture. As a general thing it is inadvisable to mutilate the tent roof, and the rim of zinc or tin around the aperture is necessarily soon bent and distorted. Where the collar around the pipe opening is made of asbestos it is obvious that the latter objections do not apply. A canvas flap may be sewed to the tent roof so as to cover the pipe opening when the stove is not in use.

Improvised huts may be warmed by the use of stoves or open fire-places. The latter method is, however, preferable, since it also largely assists in the maintenance of ventilation. In winter quarters, during the early part of the Civil War, the heating facilities varied greatly. Open fire-places were made of brick, stone, mud or sods, with chimneys of the same, with or without an additional draft made of boards, barrels, sticks and mud or hollow logs—while habitations were frequently warmed by sheet iron stoves with or without pipes, open fires in the middle of large tents, or what was still more objectionable, open kettles of embers from the kitchen fires. Toward the end of the war the employment of the open fire-place with a chimney of mud and sticks became the rule.

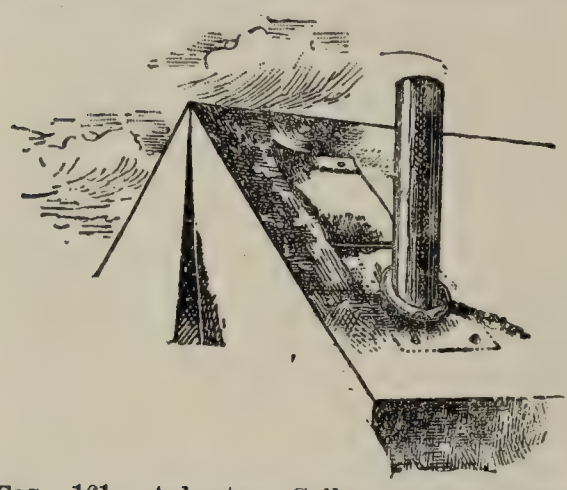


FIG. 161.—Asbestos Collar around Stove Pipe, with Protecting Flap.

A double thickness of canvas, one tent being pitched over another, is of excellent service in preventing extremes of inside temperature. In the Sioux winter campaign of 1890 the officers making use of this arrangement had no difficulty in maintaining a comfortable warmth even in the blizzard weather of the northwest. The value of this device is officially recognized in the Russian army, tents made of double canvas throughout being issued for the use of officers; the hospital tents of the English, French and German armies are also of double material, the French tent being lined with woolen cloth for the attainment of greater equality of internal temperature. The same arrangement is also of great value in tenting in the tropics, since the heat of the solar rays is diminished by the air space between the double canvas. Observations made in Cuba, in 1899, showed a temperature in a wall tent without a fly of 89° F. At the same time the thermometer registered 87° F. in a tent with a single fly and 82° F. where one tent was pitched inside another and a fly stretched over all.

Tent flies are of value in preventing leakage during hard rains, and in the diminution of the heating of the interior of the tent during hot weather. They should always form part of the canvas shelter of troops during summer or in tropical countries. In hot weather, a hospital or officers' tent is cooler if its fly be raised ten to fifteen inches at the four corners, by supporting it upon pointed stakes of sufficient length. In experiments made by the writer, the elevation of the tent fly in this manner, to the extent of one foot, lowered the inside temperature of the tent from

93° F. to 89° F. A tent fly spread in front of a tent of this pattern is an excellent protection against a hot sun—while the erection of leafy arbors above or in front of tents affords a grateful shade without interfering with air-currents. Lateral walls for such arbors, however, are in the way, impede ventilation and greatly increase the danger of fire.

Tent ropes diminish in length on being moistened; and hence should be slackened to prevent the tent pins from being drawn, or the supports from breaking, if a heavy dew or rainfall is anticipated. When dry, the ropes will require tightening to prevent flapping of the canvas, with the resulting annoyance of loosening or pulling out of the pegs. The tent pins should always be driven at a slight inclination toward the tent rather than at an angle away from it, since when so placed they hold much better in wet soil. In sandy places it is difficult to keep tents standing in a high wind, as the pegs draw; and in such instances, the guys may be fastened to stones or other heavy articles—or with small commands the Indian method may be employed, the wagons being pushed between tents and the tent ropes fastened to the blocked wheels. Bushes may be buried in the sand, the branches pointing toward the tent and one stout bough projecting above the surface to which the rope can be fastened. This method is an excellent way of keeping tents erect, as the bush forms a species of anchor. With soil of such character, a flat stone or piece of wood should be placed under the tent pole to prevent it from being forced into the ground.

Tent walls should be looped up at all times during fair weather, so that the tent area may be dried and disinfected by the solar rays. Even in cold weather, if the weather be bright, the sides of the tent should be tied up during the absence of the occupants on drill or other duty. Tents should be taken down from time to time, spread open and the inside sunned; or, as is customary in the English service, they may be roughly re-pitched on a new site and allowed to blow about freely in the wind before being replaced on the original tent space. Tents should be struck and their enclosed area sunned at intervals of three or four days, provided a change to a new camp area or fresh tent site be not practicable. In a properly arranged camp the intervals should always be sufficient to render possible the removal of the tent to a new site, previously unoccupied. Where huts are used, the doors and windows should be opened daily to permit of perflation and the entrance of sunlight, and the roof, if canvas, should be turned back.

Beds and Bedding.—It may fairly be considered that the surface of the earth, under usual conditions, is sufficiently damp to render sleeping upon it, without the interposition of some suitable protection, injurious to health. Hence the use of the rubber blanket, as a protection from soil dampness, is always to be required where opportunity is not afforded the men for raising their bodies above the level of the ground. Whenever a camp is to be occupied more than a single night, particularly if the site or weather be damp, the men should be encouraged to construct rude couches of poles, old boxes, barrels, brush or canvas, with a softer layer above of hay, straw, grass or twigs. Except in the absence of better material, green deciduous foliage should not be used for bedding; but pine, hemlock and spruce boughs make excellent and luxurious couches.

Unfortunately these soon part with their elastic properties and, when deprived of a portion of their moisture, largely increase the ever-present danger of fire. In the bivouac, where any choice is possible, it is better to spread the blankets on a spot which has been exposed to the sun than on a shaded and presumably damp locality.

Under existing regulations, where mattresses are not supplied, each enlisted man in barracks is entitled to receive an allowance of thirty pounds of straw per month as bedding; and in camps of any permanency the issue of such a quantity of straw for this purpose would no doubt be authorized. In the German army, each man is entitled to a bundle of straw at each bivouac, taken from the nearest stack. If thrown loosely on the ground during the day, along the walls of the tent, such straw or hay soon becomes damp and foul and by fermentation practically becomes a compost heap. Hence such material is best woven into sleeping mats of three or four inches' thickness; these being extremely comfortable, permitting a daily exposure to sun and air, and largely limiting that interference with proper police which the presence of loose straw can scarcely fail to induce. Straw mats are made as follows: The straw is twisted into ropes and passed around two rows of tent pegs driven into the ground, parallel to one another and two feet apart, thus forming the web. Other ropes are interlaced to form the woof, and an excellent mat may thus be made in a short time. Ordinarily each man should have two mats, one for the head and one for the legs; but if a conical tent be used the mats are preferably single. Four men in a single day can readily make suffi-

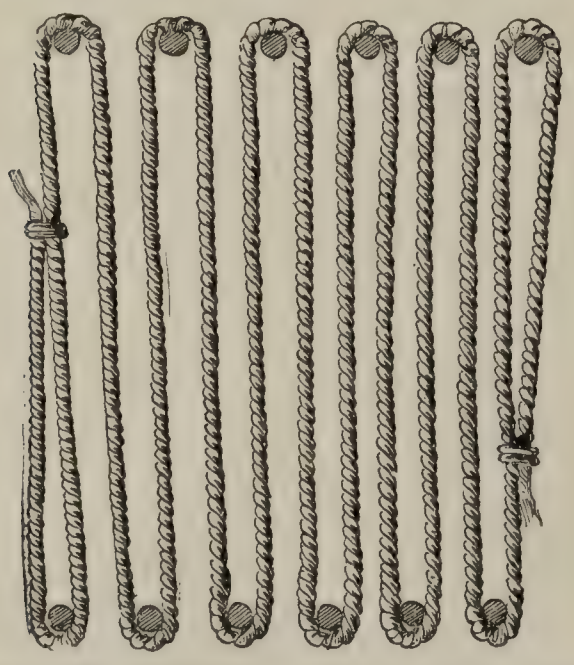


FIG. 162.—First Step in Weaving Straw Mats.

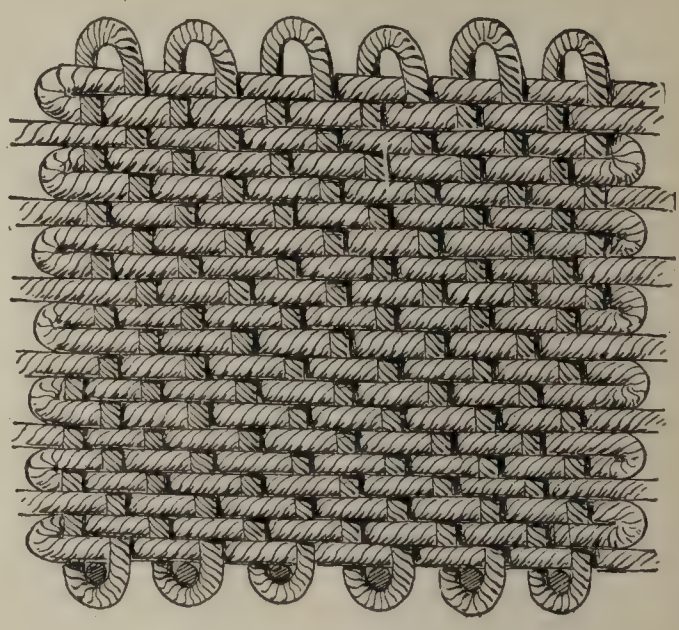


FIG. 163.—Straw Mat, Completed.

cient mats for five times their number—two twisting and two weaving. Straw employed for bedding should be aired daily, and after being used for ten days or a fortnight should be burned and replaced by a fresh supply.

In camps of any permanency, troops are now supplied with a folding canvas cot of excellent pattern. This is very comfortable, and can readily be folded up for transportation into a small package about three feet long and weighing but fifteen pounds. The cot is very strong and durable and is much liked by the men. A fold of canvas at one end furnishes a space in which hay, branches or articles of clothing can be retained to form an excellent pillow. Cots of this character, like the other contents of the tent,

should be frequently sunned in the open air. When troops are quartered in huts or frame barracks the issue of canvas hammocks may at times be desirable, since they are comfortable, cleanly and removable when not in use; with a resulting considerable increase of floor space.

Blankets and bedding should be sunned and aired on each fair day—either by hanging on supports erected for the purpose or by spreading on the sunny side of the tent roof. The former plan is preferable, as it allows access of sunlight and air to both sides of the article. Blankets are some-

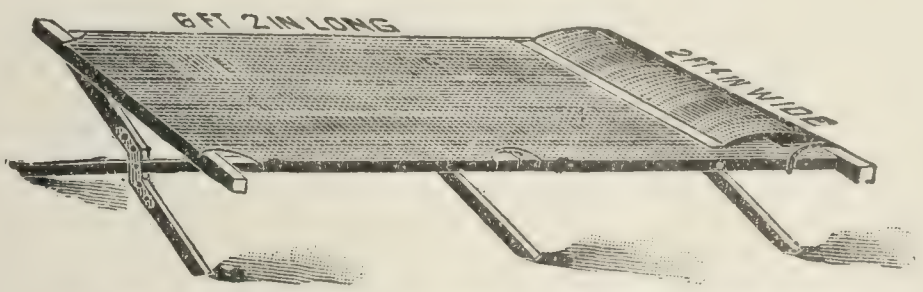


FIG. 164.—Folding Camp Cot used in the United States Service.

times hung in the shade by troops. This is of comparatively little value from a sanitary standpoint, as it is the solar rays which are germicidal.

The Excreta.—The preparation of the sinks at once upon the selection of the camp site is of the first importance. It will not do to delay their construction until the tents have been pitched and other camp duties have been performed, but, after the water supply has been guarded, a special detail should be at once told off for the accomplishment of this purpose. The completion of the sink is to be considered a matter of urgent necessity and not one of election, even if it is understood that the command is to move on the following day. Such promptness of action will largely prevent the surface contamination which would otherwise inevitably follow; and which, under conditions of infectious disease, favorable humus and suitable climatic and topographical conditions, may render a locality unsafe for military occupancy even before the camp itself has been fairly established.

Under certain military conditions, pending the construction of the latrines, a certain amount of surface pollution may become unavoidable, and under such circustances some carefully selected spot should be designated for the reception of the dejecta; due precautions being taken that all fæcal material is covered with earth by a police party at the earliest opportunity.

The latrine accommodation provided in camp should be ample, since otherwise the health and comfort of troops are unfavorably influenced and it becomes impossible to prevent the surface of the ground from being fouled. Accommodation should be provided on a higher scale in the field than in barracks, and sufficient latrines should be constructed to seat at least ten per cent. of the troops. In the German army the seating capacity of the latrines is required to be in the proportion of sixteen places to each hundred men. The multiplication of sinks is undesirable, and with large commands the construction of a separate latrine for each company should not be permitted. One sink for each battalion of four hundred men is amply sufficient, and this may be expected to be filled up in from ten days to two weeks should the camp be fixed for that length of time. It

will receive better attention than would several smaller latrines, and soil pollution is also more localized.

The general location of latrines should depend upon their proximity to the various organizations of the command, the length of time the camp is to stand, the direction of the prevailing winds and the position of the water supply. Their exact position should be determined by the officer in charge of the laying out of the camp; since if left to the discretion of company officers they are liable to be so placed as to inconvenience troops of other organizations. They should, of course, be located so as to prevent possible contamination of the water supply; and should be placed to leeward of the camp, or so that prevailing winds will not carry odors over company areas. It would seem superfluous to warn against locating the sink in such a position that it can be flooded by storm water from higher ground, yet such an error has frequently been made. Latrines should be as far removed from tents as is compatible with convenience. Under the regulations of 1863 this distance was set down as 150 paces; but a distance of 100 yards may be considered as sufficient for ordinary conditions. Obviously, the exact distance at which the latrine is located must often depend on circumstances. If too near to the tents it will be a source of annoyance; if too far, soil pollution is inevitable, for many men, particularly at night, or if affected with diarrhœa, may either wilfully or of necessity defæcate before reaching the sink.

To insist that sinks and kitchens be widely separated would seem to be unnecessary, yet for many years they were, by regulation, located in close proximity—and even recent modifications leave the matter entirely to the discretion of the commanding officer and prescribe no minimum of space to be maintained between them. During the war with Spain, as a result of lack of official regulation in this respect, in certain volunteer regiments the sinks were reported as being only a few feet distant from the kitchens. A return to the old plan of encampment, in which the latrines and kitchens were on opposite sides of the camp area and separated by a distance of 200 yards or more, is evidently highly desirable.

If the camp be for a single night only, a latrine trench of a depth of two feet will be sufficient; but where a stay of several days is contemplated the sinks must be made correspondingly deeper. For such camps a depth of about eight feet is usually considered as desirable; but under certain circumstances this depth cannot be attained. At Chickamauga a superficial rocky sub-stratum frequently prevented excavation to a depth of more than three or four feet; while troops at Tampa awaiting embarkation for Santiago were encamped where the ground water was at an even less distance below the surface. Under such conditions, it is evident that either the fæcal deposits are insufficiently covered with earth or the digging of new sinks must be an almost daily necessity. The employment of either alternative would largely conduce to the unhealthfulness of a command; since improperly covered fæcal matter emits foul odors and affords constant opportunity for the spread of infection by means of flies, while a large number of shallow sinks contract the healthful limits of a camp. The best remedy for such conditions consists, of course, in the abandonment of such an undesirable site. Should this plan conflict with military necessity then some other method for the disposal of excreta must be adopted.

The length of the latrine trench depends upon the number of men which the sink is intended to accommodate. For a single company of one hundred men a length of twenty feet is sufficient, with a proportionate increase for each additional organization. The width of the trench should be only of about two feet, since greater breadth is unnecessary and requires the use of more earth to cover the excreta. The soil removed from the sink should be piled to the rear, whence it can be scattered as needed over the deposits. The seat is formed by a stout pole, preferably one from which the bark has been removed, laid horizontally at a proper height over forked uprights. A back-rest may be formed by a similar pole, but this is often omitted. The latrine should be surrounded by a screen of brush, leafy boughs, old canvas, gunny-sacks or other available material; admittance being afforded by a valvular opening. In the British service, strips of canvas are supplied for this purpose. Where the camp is to be occupied for a night only, the latrine may be left unsheltered; but where a somewhat

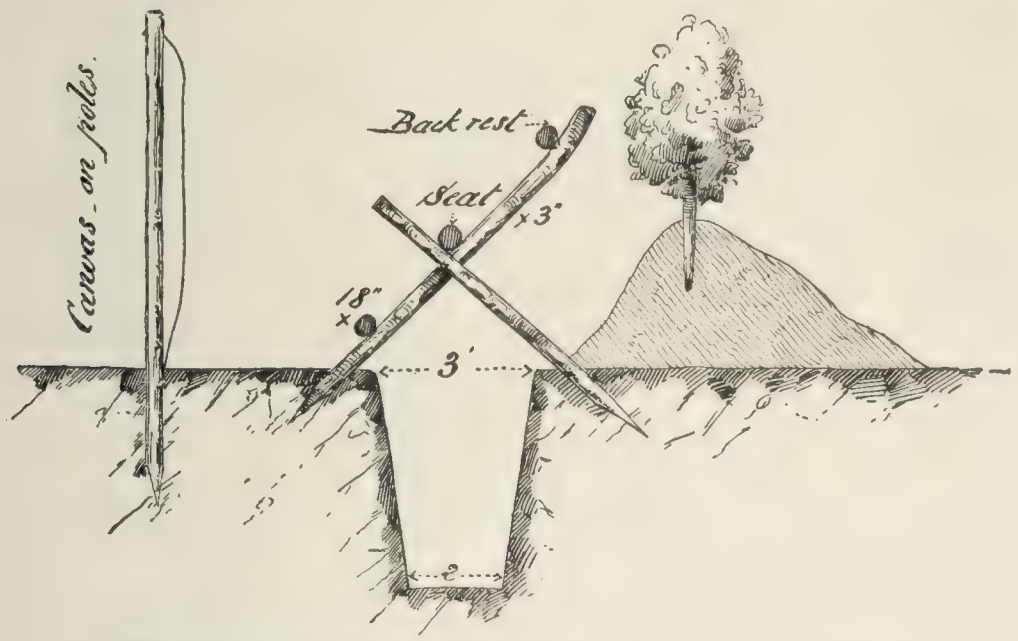


FIG. 165.—Construction of Latrine for Temporary Camps.

longer occupancy is anticipated some protection from the elements is advisable—and for this purpose the issue of canvas or boards should be authorized. In hot seasons or climates, the sink is advantageously covered with a roof of boughs to keep off the sun. This shelter rapidly dries, and on the abandonment of the camp it should be destroyed by fire.

Wherever a camp site is to be occupied more than two or three days, the latrine trench should be boxed in and converted into a closed vault, flies being thus excluded. The holes should have hinged covers, and these should be prevented from being raised to quite a right angle by a horizontal parallel bar running above the seat. This renders the lids self-closing, and at the same time prevents squatting on the seats. To avoid the soiling of the latter, a separate place for urination should be provided; a sloping trough of metal or tarred wood answering for this purpose. Access to the pit for the purpose of covering the dejecta should be had at the rear by a trap door, opening outward. Such a latrine should be both ditched and sheltered to prevent the vault from being flooded during wet weather. Under such circumstances a rain-tight box or bin for the storage of lime should be provided, while the seats should be scrubbed daily with soapsuds and a strong solution of carbolic acid or tricresol.

The care of the latrines is a most important factor in the preservation of the health of the command. The usual recommendations in this respect simply contemplate the covering of the dejecta with loose earth once in twenty-four hours, usually at night. This attention is not sufficient except in rare instances, under favorable conditions of climate, season and soil and where but relatively few men are using the sink, and much greater and more constant care should be required—even in the nightly camps while on the march. As a general rule, the old Mosaic law requiring each individual to cover his own fæcal discharges should be enforced. The chief objection to the covering of his excreta by the individual soldier is that of the more rapid filling up of sinks and the necessity for the excavation of new ones. This, however, is the argument of the company officer rather than the sanitary inspector, and labor thus economized is largely at the expense of the health and comfort of the command. Care should be taken that unnecessarily large quantities of earth are not employed in covering the dejecta and that the amount used is properly distributed. In camps of anything but a transient nature, it should be the duty of some specially detailed soldier to visit the sink one hour after each meal and ensure that the dejecta are fully covered; reporting its condition after each visit to the responsible officer. In addition, the condition of the latrine should be personally verified by a commissioned officer at least once during each twenty-four hours. When the trench is filled within two or three feet of the surface its use should be discontinued, and earth thrown in and well raised to mark the site. Sinks should always be filled in immediately prior to the resumption of the march.

The care of latrines has, in the past, devolved upon the soldiers themselves. The repugnance and opposition to the performance of such duty manifested by volunteer troops, however, together with the inefficient manner in which the sanitary police has been carried out by them, elicited a general order, in 1899, charging the Quartermaster's Department with the duty of policing the camps established for the muster out or organization of such volunteer forces. This duty includes the construction of latrines and the disposal of their contents, as well as of all garbage and waste; and for this purpose the purchase of the necessary apparatus and the hiring of civilian labor was authorized. The practical results of this experiment have been very successful, and with raw troops this plan will probably be continued in the future.

In the construction and location of the sinks, due care should be taken so to arrange the screens as to prevent the wind from blowing soiled scraps of toilet paper from the trench, and thus distributing possibly infectious material during their course through the camp, perhaps ultimately to gain entrance into a water supply. Should such paper have been scattered, it is to be promptly collected and destroyed. The fragments may be picked up on a pointed stick, placed in a gunny-sack and the latter burned with its contents at the end of policing. It is well in this connection to emphasize the desirability of issuing a reasonable quantity of toilet paper as part of the allowance of the soldier, since the use of such material is largely conducive to both comfort and cleanliness. The employment of objects like sticks, grass or leaves may induce or aggravate irritation of the rectum or anus; while, with the lack of washing facilities in camps, their use could

scarcely fail to render the person and hands possible agents for the dissemination of disease, through the subsequent handling of utensils used in common, clothing and other articles.

With a moving command the disinfection of the latrines is usually unnecessary. In the German army, which never bivouacs two consecutive days on the same spot, no disinfection of sinks is practiced. In camps of a more permanent character, during the occurrence of infectious disease, the disinfection of the sinks should be daily carried out—and under such circumstances it is particularly indicated during warm weather, when the danger of dissemination of infectious material by flies is constantly present. If milk of lime is used for this purpose, it is well not to be content with liming the dejecta but to pour a thick whitewash over the walls of the trench, so as to leave no resting-place for flies. In the absence of any chemical disinfectant, the bottom of the sink may be loosely covered with dry straw, hay, leaves or other inflammable material, and

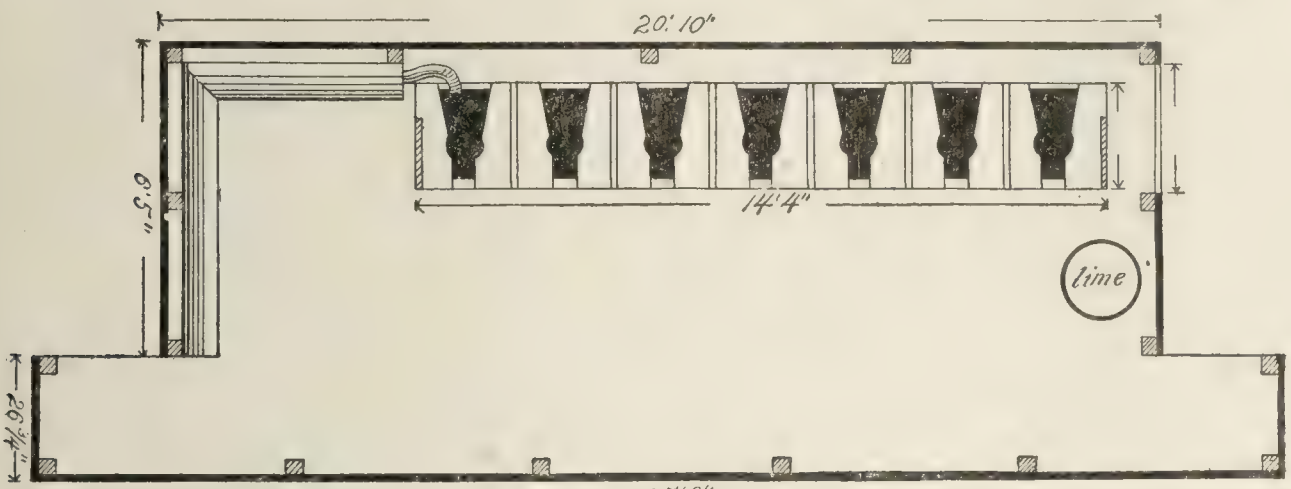


FIG. 166.—Ground Plan of Trough Latrine, Showing Seats and Urinal.

this set on fire. To facilitate this procedure, crude petroleum is sometimes sprinkled over the whole. The general methods for the disinfection of fæcal matter are discussed elsewhere.

The employment of excavated sinks fully meets the needs of moving commands, and furnishes, in fact, the most practicable method for the disposition of dejecta during active campaign. If troops are to occupy a camp for but a few days, such sinks, slightly elaborated in detail, are still amply sufficient—but for camps of a semi-permanent character, particularly camps of mobilization and organization, latrine trenches should never be employed and other methods for the disposal of excreta are imperatively required. To meet this need, a plan for camp latrines has been devised by a board of medical officers—the system having proved itself as satisfactory in practice as it is excellent in theory. This arrangement prevents soil pollution by either urine or fæces, accomplishes their prompt disinfection and deodorization, and is at once cleanly, simple and convenient. It is not, however, applicable for winter use in cold climates. The system includes the provision of a trough, urinal, latrine shed and excavating apparatus. Each latrine is intended to meet the needs of one hundred men; which number excrete about twenty-five pounds of fæcal matter and forty gallons of urine during each twenty-four hours. One excavating apparatus is expected to be sufficient for the needs of each brigade.

The trough, parabolic in cross-section, is of the following dimensions:

length, 14 feet; width at top, 22 inches; depth, 18 inches. It is made of sheets of galvanized iron, well riveted and smoothly soldered at joints and ends. The front and rear sides of the trough are given additional strength by means of an iron rod one-fourth of an inch in diameter, over which the

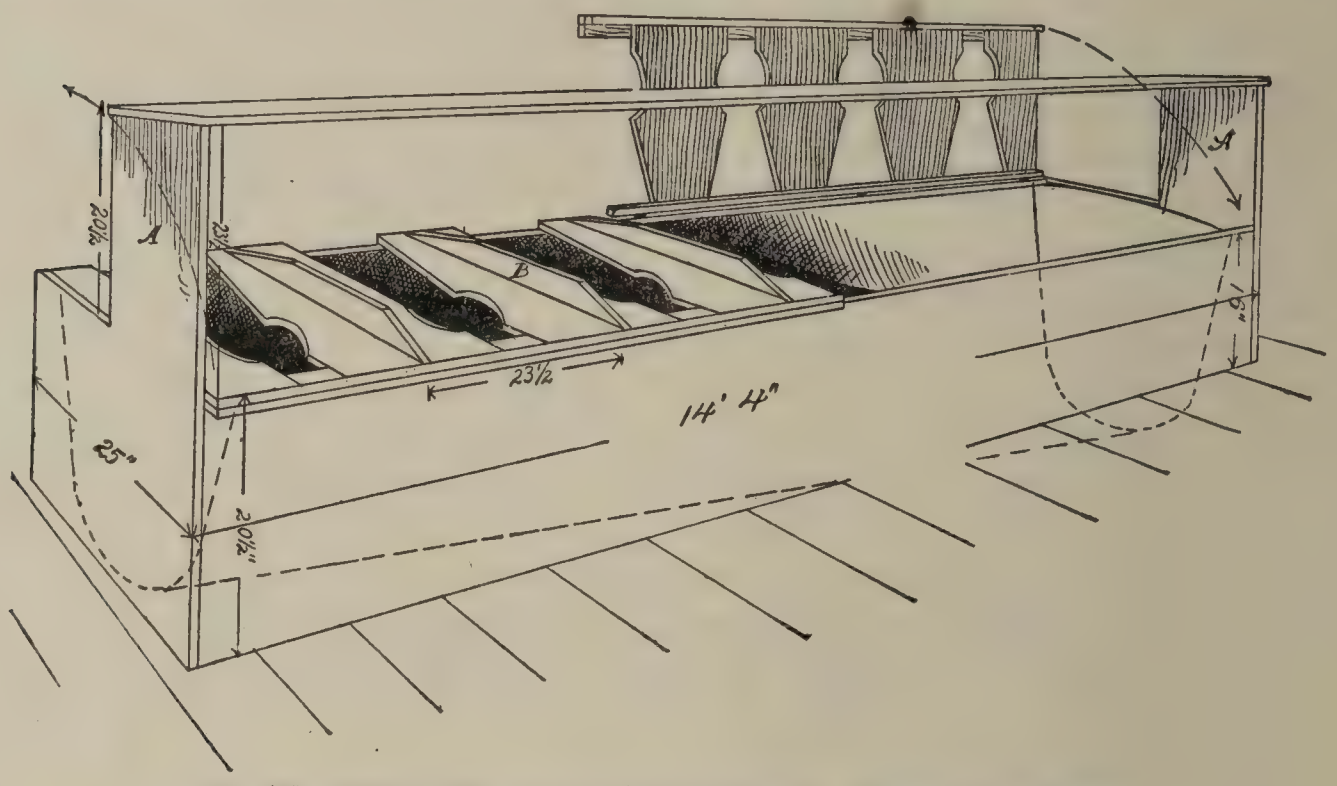


FIG. 167.—Perspective View of Latrine Trough. Section of Lid Open.

edges are turned. The general shape of the trough is such as to present a curved surface throughout; avoiding corners in which material could collect and thus ensuring its easy emptying and cleansing. To better accomplish the latter, one end of the trough is raised to a height of four inches above the level. This trough is supported by a framework consisting of four pieces so cut as accurately to fit its surface; the four frames being placed one at either end of the trough and the other two equally spaced.

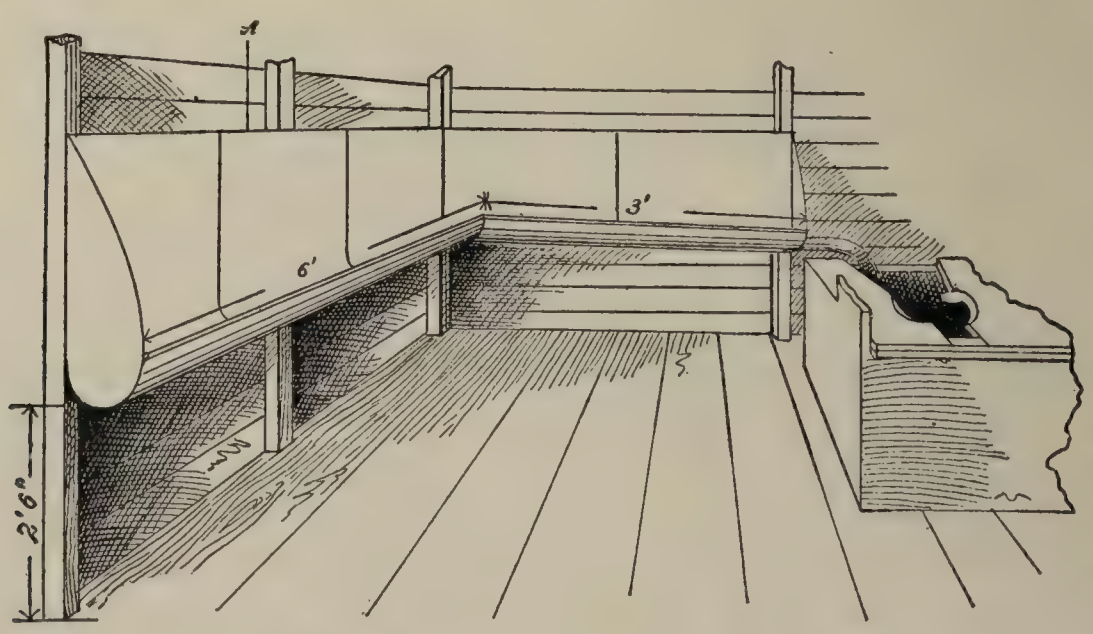


FIG. 168.—Urinal in Trough Latrine.

These frames are joined at the rear of the trough by two pieces 1 by 3 inches, one of these at the bottom and the other at the top of the frame. In front, the trough is completely boarded in by 1-inch material. The lid consists of two sections, each 7 feet long and containing three and one-half openings, or seven openings in all. It is made of 1-inch material; the

several pieces being held together, in front and rear, by a batten 1 by $1\frac{1}{4}$ inches wide. Each section of the lid is provided with three hinges at the rear. The ends of the trough are boxed in and give support to a board 1 by 12 inches, rising to a height of $23\frac{1}{2}$ inches in front and above the lid; the upper edge of this board being cut sloping to the extent of three inches. These end boards give support to another board, 14 feet 4 inches long by 12 inches wide, which is intended to prevent men from standing on the lid. This board should also be braced from the roof of the latrine shed.

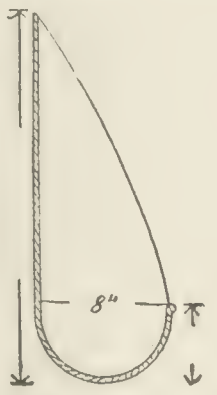


FIG. 169.—Cross-Section of Urinal.

It is thus seen that the trough is enclosed by a complete framework, which is intended to secure support while in use and safety during transportation, should the latter become necessary. When placed in position, the height of the upper end of the trough above the floor, including lid, should be $20\frac{1}{2}$ inches; at the lower end 16 inches. This necessitates an opening, in the floor of the latrine, corresponding to the width and length of the framework of the trough. The rear margin of this opening should be at least 4 inches from the studding of the rear wall of the building, so as to permit the raising of each section of the lid. The lid of the trough is divided into seven spaces, each 1 foot $11\frac{1}{2}$ inches in breadth by 1 foot 10 inches in depth; the sides of the spaces being indicated by a vertical board 4 inches in height and beveled at each end. Each space is provided with an opening, so shaped as to prevent, as much as possible, the soiling of its edges by fæcal matter. This opening, 4 by 3 inches in front, expands to a width of 8 by 8 inches, this part having its edges well beveled, and is

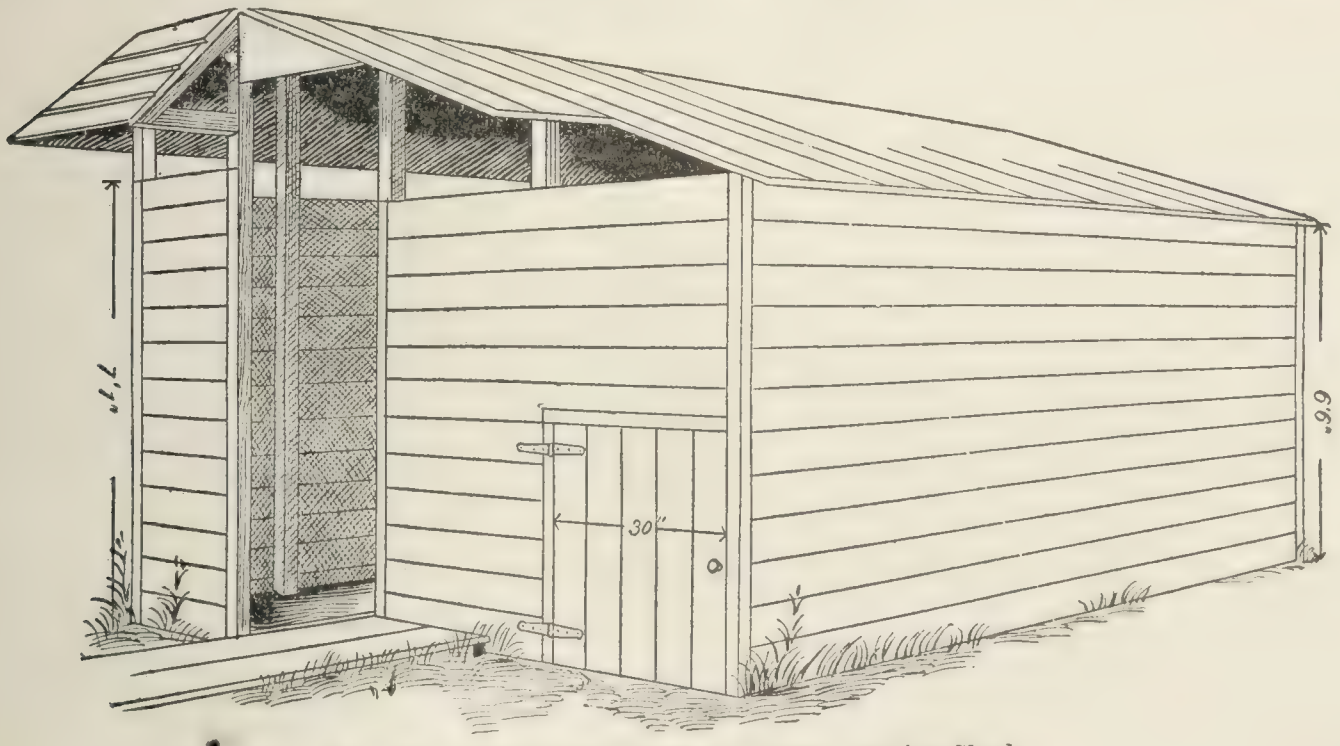


FIG. 170.—Perspective View of Trough Latrine Shed.

then extended backward to the rear of the trough and cut away as much as possible without weakening too much the strength of the lid. In other words, both the front and the rear of the ordinary watercloset seat is largely cut away. This is intended to avoid both wetting the front of the seat with urine and its rear edges with precipitate diarrhœal discharges.

The urinal consists of a galvanized iron trough fastened to the end and rear walls of the latrine, at a height of 2 feet 6 inches from the floor. It measures 9 feet 7 inches in length by 8 inches in width, and has a depth of 4 inches. Its rear side is extended 18 inches upwards, so as to protect the wall of the latrine from any possible contamination with urine. It has a fall of five inches, and empties into the upper end of the large trough by means of a pipe two inches in diameter.

When ready for use, water should be poured into the larger trough until it has a depth of at least two inches at the upper end. To this is then added one-sixth of a barrel of lime and the two are well mixed with a wooden paddle. Lime should, also, be freely sprinkled in the urinal.

The latrine shelter consists of a frame building 8 by 20 feet, inside measurements. The height of the roof at the rear is 6 feet 6 inches. The front wall of the building is prolonged 2 feet at either end, and is provided with a projecting hood throughout its entire length. This hood protects an opening 20 feet in length by 12 inches in width, intended for ventilation and lighting; and which, in warm climates, should be extended along the sides and rear of the building so as to insure a better circulation of air within the closet. The lengthening of the front wall allows for a protected entrance, 2 feet in width, at each end of the building, for persons and also for barrels containing disinfectants. A door 3 feet 6 inches by 2 feet 6 inches is provided at the end of the closet, opposite that of the urinal, through which suction hose can be introduced for the removal of the contents of the trough. Through this door the trough, enclosed in its frame, can be removed whenever such action becomes necessary. The closet is properly floored and should be lighted at night by a suitable reflecting lantern.



FIG. 171.—Odorless Excavating Tank Wagon, with Detachable Pump.

The excavating apparatus of this latrine system consists of a strongly constructed wagon-bed, mounted on broad-tired wheels, supporting a water-tight tank having a capacity of 500 gallons. A 6-inch opening at the rear end of the tank, controlled by the turning of a lever, serves for the purpose of emptying the contents. Accompanying this wagon is a pumping apparatus, consisting of a cylinder capable of withstanding high pressure, two 20-foot lengths of 3-inch rubber hose, with two pairs of brass couplings and a removable handle for working the pump. The latter is single acting and in form a straight cylinder provided with one fixed valve (the induction), and one movable—the latter attached to the piston and moving in the center of the cylinder; the openings of both valves being in a

direct line. The passage of material through the pump is therefore direct and without counter currents; and such is its capacity for passing obstructions that sticks, stones, shavings, rags or other obstructions, even if of the size of a pair of heavy cloth trousers or a full-size army blanket, are pumped through with ease. In fact, any object not too large to enter the suction hose will pass freely through the valves without interfering with their action.

This pump is provided with side bars for lifting purposes, and is supported on a pair of strong iron wheels. When in use, it is connected at each end of its cylinder with one of the ends of the 3-inch hose. One free end of the hose is then connected with the pipe on top of the tank, and the free end of the other length of hose placed in the trough to be emptied. The pump is rapidly worked by one or two men and the contents of the trough are quickly pumped into the tank, a gallon or more of water being placed in the cylinder of the pump before the connections are made.

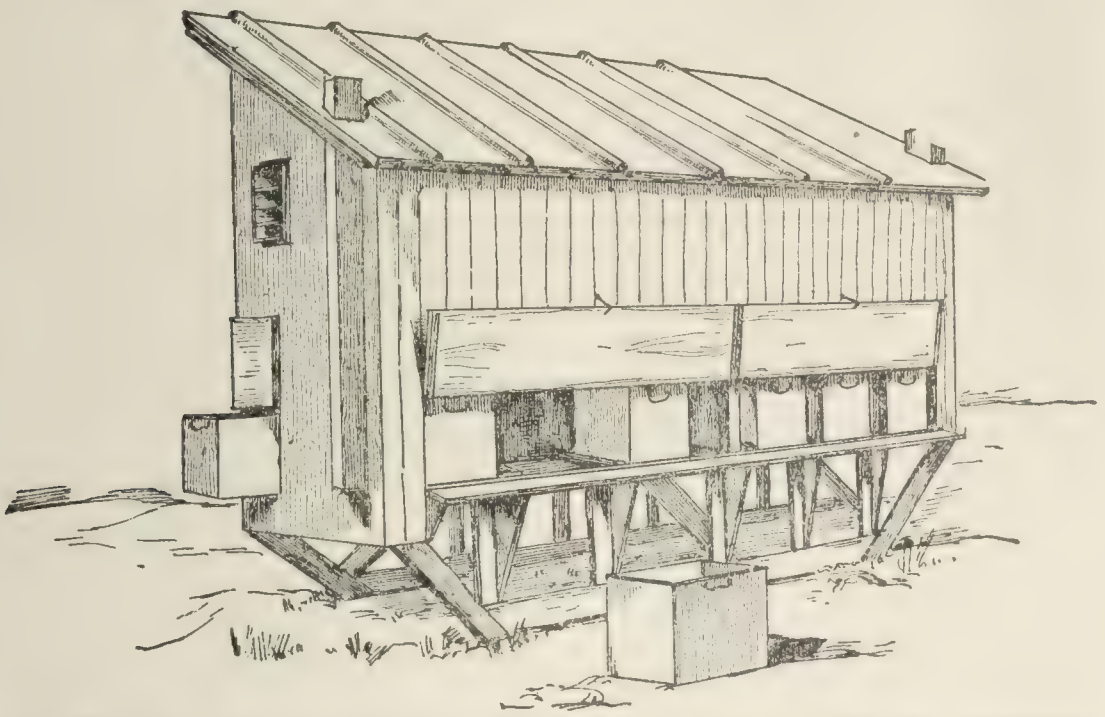


FIG. 172.—The Can Latrine System, as Used in the Camp at Lexington, Kentucky.

As soon as the trough has been emptied, the end of the hose is elevated and securely closed with one of the couplings provided for that purpose. This length of hose is now disconnected, its end closed with the coupling and the end of the pump also tightly closed by a valve provided for that purpose. The same steps are taken in detaching the other length of hose from the tank, and in this way none of the contents of the pump or hose are spilled on the ground. The two lengths of hose are placed in position along the sides of the tank, the pump is hitched to the rear axle of the wagon by the attachment provided, and the excavator wagon driven to the next trough which is to receive attention. If the command is removed to another camp the pump may be drawn at the rear of the wagon. Three men are required to handle each excavating apparatus.

Various other systems for the disposal of the excreta have also been employed in our standing military camps, the types varying with the ingenuity of the designer and the material and facilities at hand. These arrangements were many of them modifications of the bucket system, as shown in the accompanying illustration of a latrine in use in the camp at Lexington, Ky. This system as a whole, when properly supervised, gave

fairly good results—but was quite inferior to the trough system, already described. The receptacles were difficult to disinfect or keep clean, and by their careless handling the pollution of the soil in the vicinity of the latrine was very liable to occur. The system possessed, however, the great military merit of being readily improvised and of not requiring the provision of elaborate special apparatus. It is used to a considerable extent in the French army, and is also employed under certain conditions in the British service.

A removable galvanized iron tub has been recommended for use in receiving the discharges of the sick in field hospitals. This tub has a diameter and depth of 19 inches. It is provided with a wooden seat and lid, capable of being securely fastened by brass clamps, so as to prevent spilling of the contents during removal to the disinfecting station; a second lid is perforated with a pipe for the entrance of steam or boiling water and also a discharge pipe for the escape of the contents. When in use, this tub should contain several gallons of milk of lime.

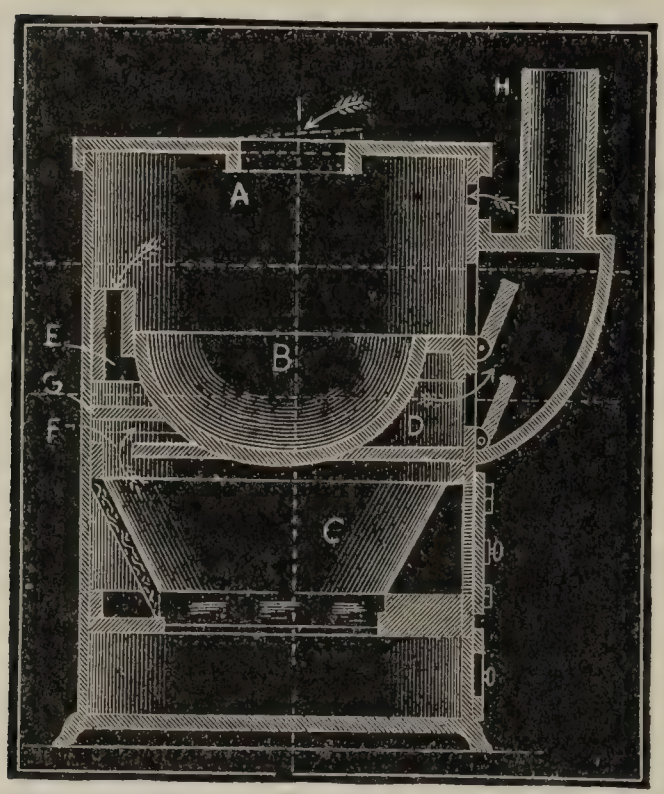


FIG. 173.—Bissell Incinerator, in Vertical Section.

From a sanitary standpoint the disposal of fæcal matter, under any conditions, is best accomplished by cremation. Bearing this fact in mind, a number of attempts have been made to perfect apparatus for the destruction of excrement by fire, of such construction as to render practicable their use by troops in the field. Of these, perhaps the most satisfactory is the Bissell Incinerator, which has recently been given a careful trial in the camps of instruction of the New York National Guard. Reports made upon this apparatus show that it is capable of efficiently cremating its contents, without the production of any very offensive odor, within the space of an hour. Garbage may also be incinerated, the length of time depending upon the nature of the material to be destroyed and the amount of moisture present. The details of construction and method of operation are simple and are plainly shown in the accompanying illustration, the letter A marking the upper space between the pot or receptacle B and the top of the casing; C is the fire-box and D is the draft passage; E is a passage leading down from an upper space A into the draft passage D, and F is an opening leading from the fire-box up into the same passage D. A deflecting wall G is located midway between the passage E and opening F. The odors from the material in the pot or receptacle are drawn down through the passage E by the draft, as indicated by the arrows, and then pass through the passage D into the chimney or smoke pipe H, and the products of combustion from the fire-pot C pass up through the opening F into the same passage; mingling therein with the odors and gases from the upper space A, which are destroyed before passing into the pipe H.

The apparatus, as made for military use, has a capacity of 5 gallons and a weight of 115 pounds. When the incinerator is full, the wooden seat is removed and replaced by an iron cover. Fire is made in the fire-box, wood generally being used, and the back of the draft near the chimney-pipe is opened. It is stated that the currents of air passing through the apparatus during accumulation of the fæcal matter are sufficient to carry off all odors through the smoke pipe.

For camps of instruction or mobilization this apparatus appears to have given satisfaction, and it may serve a useful purpose under the conditions in which the trough latrine system or the Smith crematory—later discussed—would be successfully employed. Recently, however, the effort has been made to render this apparatus so transportable as to enable it to accompany marching troops, and special latrine wagons are now in use in the New York National Guard, each wagon containing eight individual

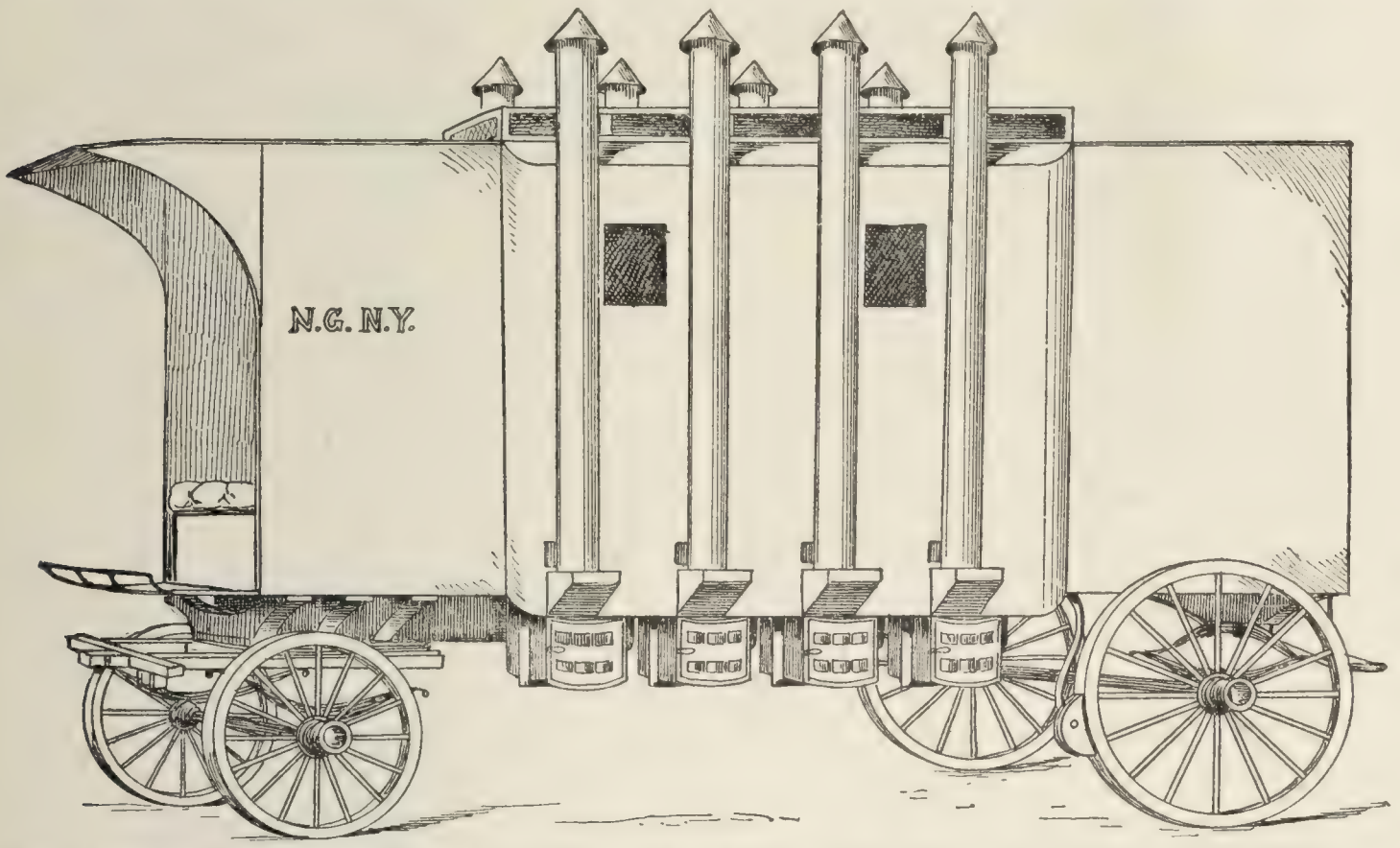


FIG. 174.—Bissell Incinerator Wagon for Excrement and Garbage, as Used in the National Guard, State of New York.

incinerators with fuel boxes. These latrine wagons are large and cumbersome, and weigh, complete, 4,000 pounds each. There are many practical objections to the use of such wagons in the military service. They are intended especially for marching troops, but simple excavated latrines are in all respects excellent under just such circumstances. The allowance of latrine seats in one of these wagons, if it were assigned to a company of 100 men, would only be eight per cent.; yet even with this scanty allowance there would be required, for the needs of a division of 10,000 men, no less than 100 latrine wagons. Such an addition to the train would seriously impair the mobility of a military force, and the wagons being heavy, they would require some 400 animals for their transportation. Further, it is obvious that they could not closely accompany a marching column, but would have to form a part of the general wagon train; and thus they would not reach the camping ground until some time after the arrival of the troops, by whom, in the absence of latrine facilities, the locality

would inevitably have been more or less contaminated. This latrine wagon is an excellent example of the many devices proposed for army use, which, though they may be excellent in theory, are totally impracticable under the actual conditions existing in the military service.

The important part played by urine in the spread of infectious disease, more especially typhoid fever, has until recently been practically unrecognized in the military service, and hence the me thods for its disposition in camps have been largely neglected. With the discovery, in 1898, that enormous numbers of the specific micro-organisms are often present in the urinary excretions of typhoid fever patients, the disposal of the urine in any but the encampments of marching troops assumes new significance and importance to the military sanitarian. With respect to the destructive epidemics of typhoid fever occurring in the home camps during the Spanish-American war, the medical board engaged in their investigation considered

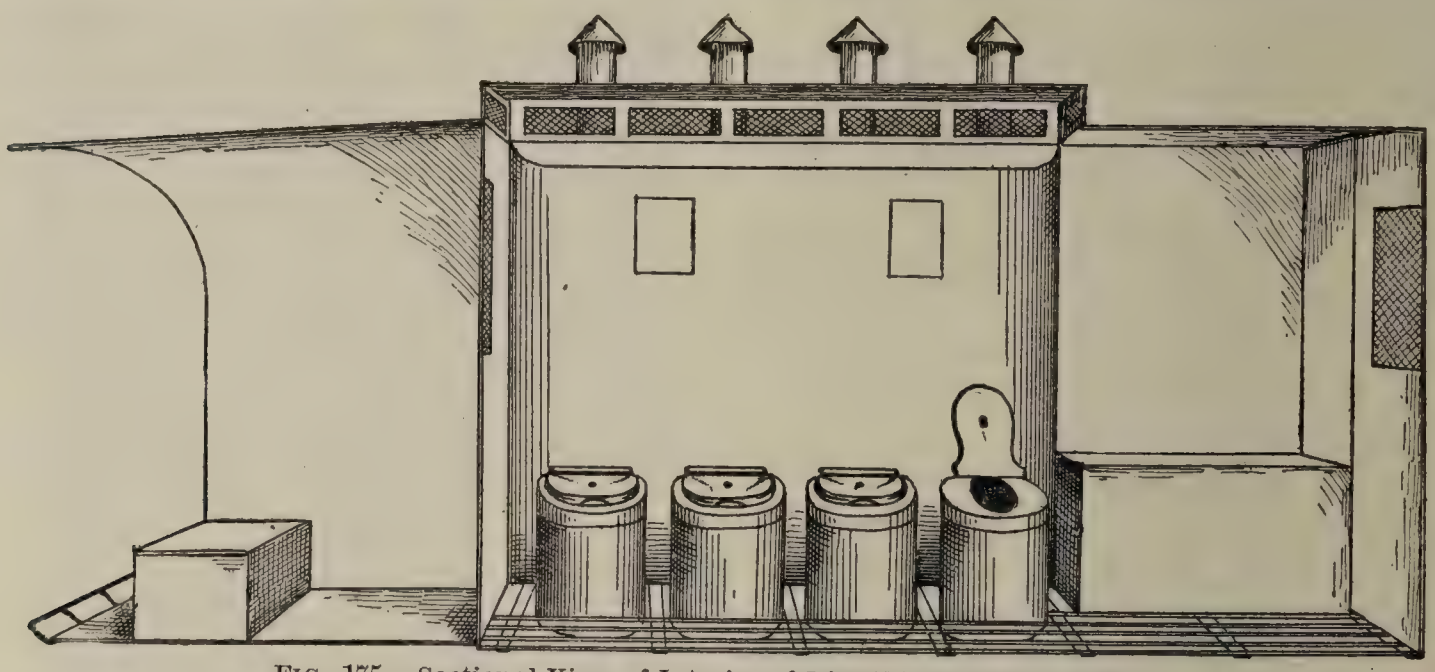


FIG. 175.—Sectional View of Interior of Bissell Incinerator Wagon.

the pollution of the camp site by infected urine as one of the most potent factors in their causation.

Satisfactory arrangements can with difficulty be made in camps to prevent soil contamination by urine; not only on account of the facility with which the operation is accomplished and the comparatively slight danger of its detection, but also because of the idea which has always prevailed as to the harmlessness of such action. Fæcal matter is repulsive to both sight and smell, while urine, passed upon the ground, is neither; and the soldier who fails to resort to the sink or urine tub rarely leaves traces behind him unless there has been a recent snowfall. Each delinquent, if he considers the matter at all, imagines himself to be the only one committing a sanitary fault of this character, and relieves his conscience by the thought that such an individual act can have no effect upon the general welfare; failing entirely to appreciate the fact that his comrades are probably looking at the matter from identically the same standpoint.

If the weather be good, the sinks receive the greater portion of the urine voided during the day. In bad weather, some comparatively sheltered spot, usually between tents or huts, is often selected for urination; while at night all parts of the company area are liable to pollution. Indiscriminate contamination of the camp site of this character is a marked

characteristic of raw or ill-disciplined troops. It should be specifically prohibited in orders; the infraction of which should be followed by severe punishment. To limit contamination of the camp area, it is sometimes well, with raw troops, to designate certain places, nearer than the sinks, for the reception of urine—and in all fixed camps, urinals should be established near the canteen and mess shelters. Night-tubs for the reception of urine are essential in a standing camp; although if convenient for all they are liable to be too near to some. For this purpose, charred or tarred tubs or half barrels—or better yet, barrel-shaped galvanized iron receptacles—should be employed. These should be placed in the center of the company streets at retreat and be removed at reveille; being emptied, disinfected and exposed to the sun during the day. While in use, they should always contain a sufficient amount of some disinfectant solution, preferably milk of lime. The location of the urine tub as well as the latrine should be marked at night by lanterns to prevent accidental soil pollution, and with semi-permanent camps the locality in which the night tub is placed can advantageously be cemented.

In general, with regard to the observance of sanitary rules as to the disposition of excreta, untrained troops are difficult to control and it is almost useless to appeal to their intelligence. Concerning the outbreak of typhoid fever among the volunteer troops at Camp Alger, Va., in 1898, it was reported as follows: "By the careless and filthy habits of the men the woods surrounding the camp became generally the receptacles of fæcal matter. Sentinels who were placed to prevent this use of the surroundings of the camp failed to report their comrades; and I do not believe that in a single instance an arrest took place for this cause, which was one of the principal ones of the infection of the camp." With such undisciplined troops, it is evidently necessary that the latrine should be so comfortable and convenient that it will be preferred by the soldier to any other point for the disposition of his excreta. In this connection, it should not be forgotten that savages, although their habits may be highly unsanitary, remove their habitations from time to time as their surroundings and camp areas become filthy and polluted. Raw troops living like savages in their disregard of sanitary principles, without moving camp as often as do these savages, cannot fail to be scourged by epidemic disease as a result of their ignorance and neglect.

Garbage and Refuse.—Kitchen garbage should always be kept separate from dry rubbish. It should never be thrown upon the ground, and should not be buried within the limits of the regimental area unless the camp is positively known to be of a transient character. Kitchen refuse usually contains about eighty per cent. of moisture, and if present in large quantity its destruction by the kitchen fire alone is scarcely practicable. There is, in addition, a large amount of greasy water which requires disposition, and this, like garbage, should never be thrown upon the camping ground to attract flies and contaminate the soil. In standing camps, all kitchen waste should be placed in tight receptacles; for warm weather or climates these are preferably made of galvanized iron, provided with lids and capable of being both readily opened and snugly closed. Such receptacles should be placed on raised platforms for the better protection of themselves and the ground beneath them, and should be emptied

at least once daily. Before being returned to use they should be washed and disinfected. Under no circumstances, in such camps, should the garbage be buried; and least of all, to reduce its bulk, should it be dried by being thrown on the ground—as was done in certain volunteer organizations in the late war. Besides the resulting soil pollution, such action greatly increases the number of flies, which, despite all efforts, infest a summer camp of any permanency.

The proportion of fluid in ordinary refuse from the camp kitchen is usually considerable; and with small improvised crematories this is a practical difficulty in the way of the destruction of garbage by fire. Under such circumstances the separation of the solids from the fluid portion becomes desirable. This can readily be done by pouring it over a strainer of any kind. The Conley garbage receptacle is an excellent arrangement for this purpose. It consists merely of two galvanized iron cylindrical containers of the same diameter, each of about one-half barrel capacity. In one of the containers the bottom is replaced by a heavy wire mesh, and this fits into the top of the second container. The upper receptacle is

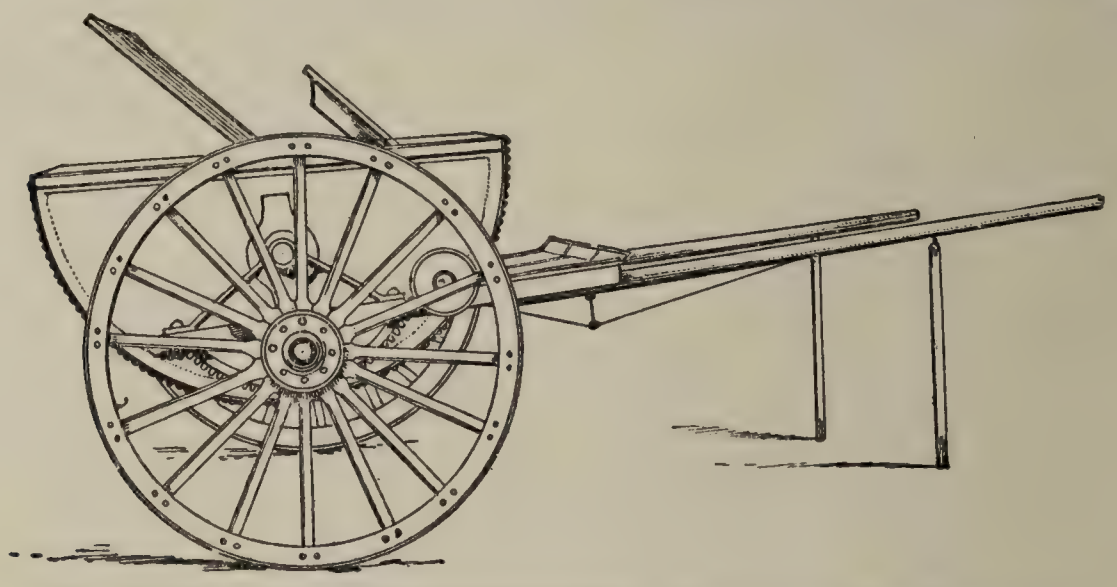


FIG. 176.—Sanitary Garbage and Refuse Cart, Used in the United States Army.

closed at the top with a lid. The solids of the garbage are separated out and are retained in the upper container in a condition suitable for cremation. The fluids run through into the lower can and are then readily removed for suitable disposition. These two containers can be firmly locked together to facilitate handling.

Carts or wagons for the removal of garbage to the place of disposition should be made in special designs adapted to their particular purpose, and the collection of garbage and refuse with the aid of the leaky and offensive wooden barrels of an open wagon can have no place in the proper sanitary policing of the military encampment. A somewhat popular method of disposal of garbage in large camps has been its presentation or sale by company cooks to irresponsible civilians, who collect and cart it through the camp, without regard to sanitation, in vehicles and receptacles not at all suited to the work in which they are employed. Such a disposition of kitchen refuse should never be permitted. The general health demands that its removal shall be accomplished in vehicles which do not absorb moisture, are water tight and as nearly as possible air tight, are easily cleansed and readily loaded and discharged of their contents. Such carts, in the proportion of one to each brigade, should be issued for use

with troops in the field under all conditions except those of actual campaign. In large camps of mobilization or organization, and particularly where troops have gone into permanent camp or winter quarters, the employment of such special means of conveyance is imperative in the limitation of soil pollution. A cart of this character has for several years been in use in various garrisons throughout the United States and should not be permitted to find its only field of applicability in the routine of a well-ordered military post. It is built of sheet iron, is water-tight, and is provided with closely fitting lids having wide flanges and capable of being locked in position. The axle is encased in a steel tube which passes through the body of the vehicle. The weight of the cart is 1,500 pounds and its capacity 54 cubic feet. The body is well balanced, and is adjustable at any angle for the discharge of the contents and convenience in cleansing.

A place for the final disposition of refuse should be set aside upon the establishment of the camp. This should be at a considerable distance; varying, however, with the climate, season, size of the command and amount of available transportation. It should always be outside of the camp area, placed to leeward of prevailing winds and so located as to avoid possible pollution of the water supply. Even upon this spot, kitchen waste and other organic refuse should never be thrown upon the surface of the ground or dumped in ravines and gullies. Such accumulations of filth, in the presence of heat and moisture, rapidly undergo fermentation and decay. They form favorable culture media for pathogenic bacteria, and from their general composition the presence of those causing the commoner infectious diseases may safely be presumed.

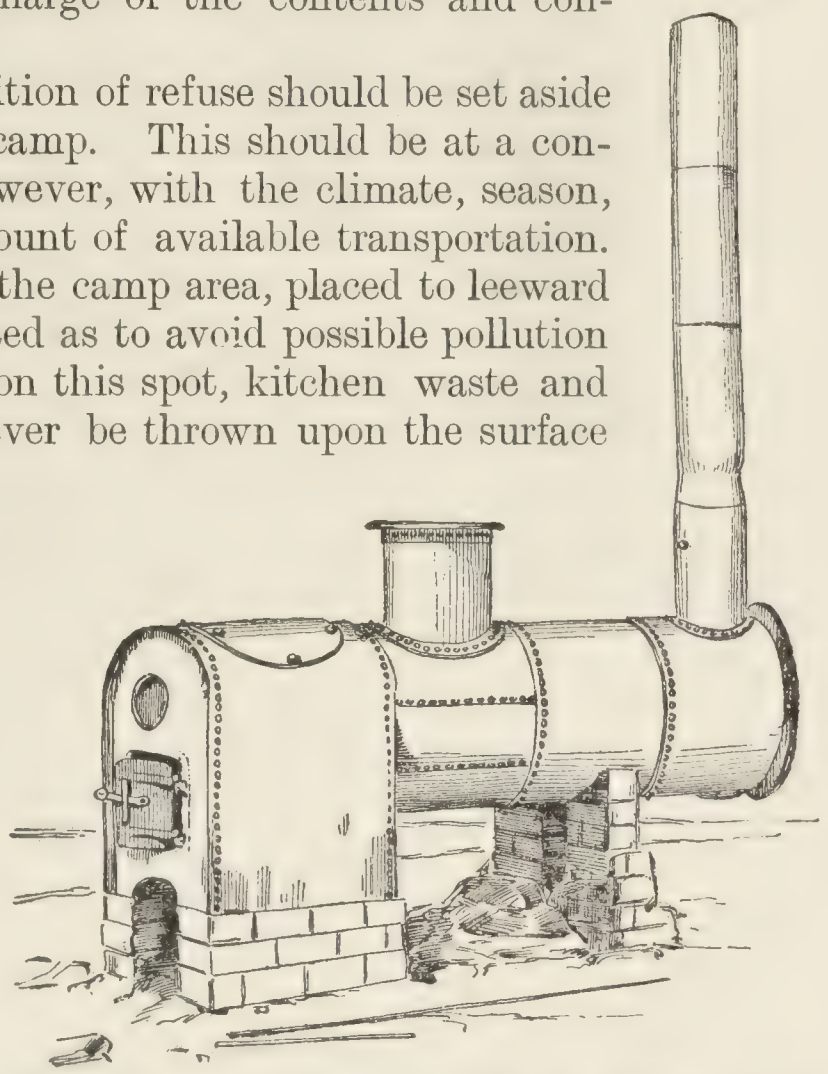


FIG. 177.—Improvised Crematory Used at Camp Columbia, near Havana.

In standing camps, cremation is the only proper method for the destruction of garbage. Stable manure, after the daily collection, should be carted to the general dumping-ground and there burned; as should also all slaughter-house offal and dead animals. All such refuse as straw, empty tins, rags or bones should be subjected to the action of fire; any incombustible residue being buried.

In the field, the methods for the cremation of refuse vary from the use of the fire of the company kitchen to the employment of specially constructed crematories. An effective means for the destruction of garbage, much used in several of the large camps and in the municipal sanitation of Santiago while under military control, consists in its incorporation with more combustible material, such as straw or manure, and the saturation of the whole with crude petroleum before ignition. In one military camp, during the late war, a number of old steel rails were so disposed as to form

a platform, under which a brisk fire was maintained. The garbage was thrown on this platform and was said to have been promptly and efficiently destroyed. In the Crimean War, the English burned their camp offal in improvised incinerators made much in the fashion of lime kilns; and a similar method was in use in the camp of the 1st Army Corps at Lexington, Ky. In the camp of the 7th Army Corps, at Havana, several crematories constructed from old boilers were in use and were said to have excellently accomplished their purpose. They were, however, liable to become clogged by an incombustible residue unless given careful attention.

Among the more elaborate forms of apparatus for the combustion of garbage and camp refuse, the Conley field crematory is excellent. This crematory is made up of but few parts, and these can be readily separated from each other and packed so as to occupy but small space. The mate-

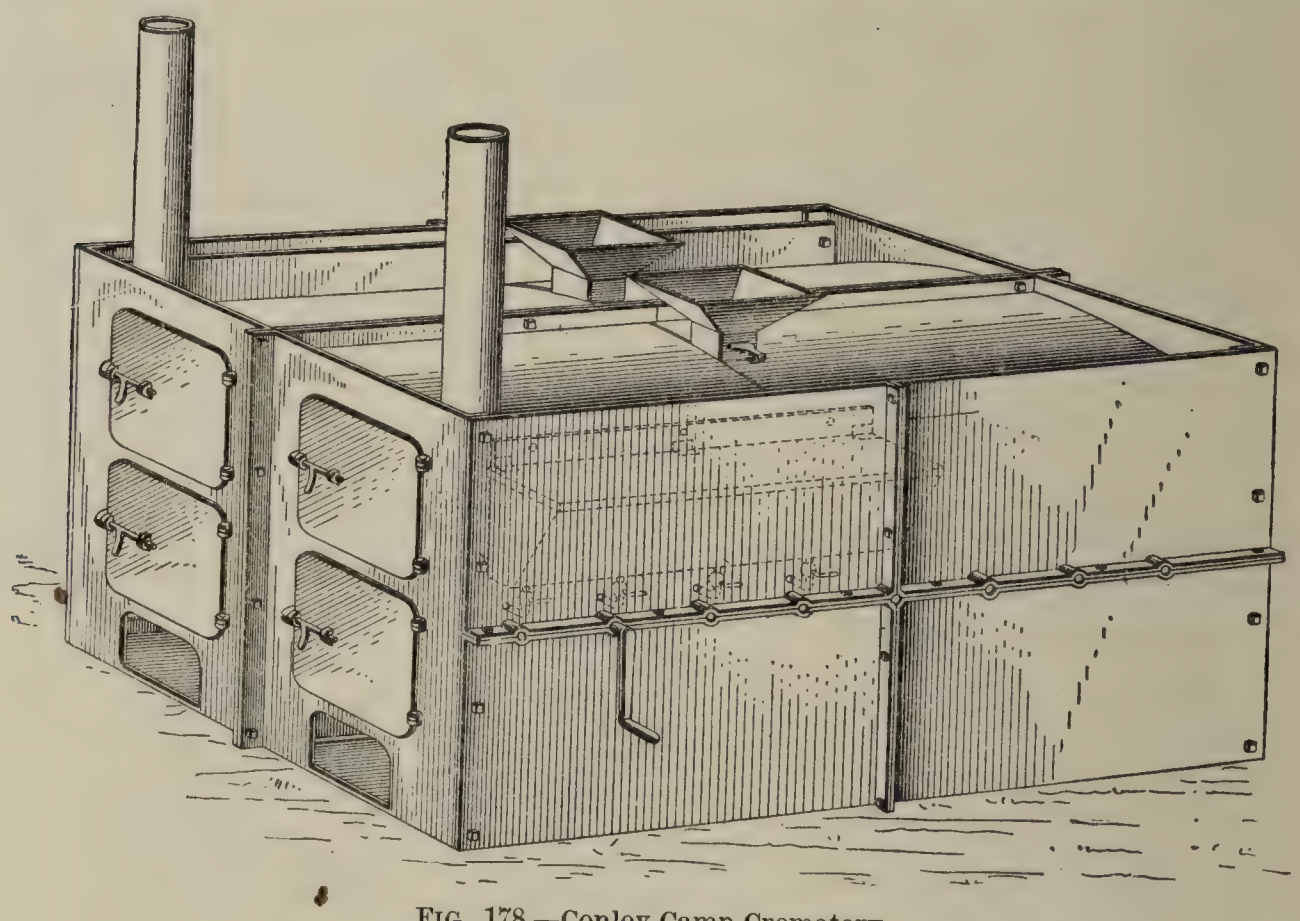


FIG. 178.—Conley Camp Crematory.

rials employed in its construction are sheet iron and asbestos. The side walls of the apparatus are each made of four plates, having flanges which enable them to be fastened together with stove bolts. The front and rear walls are attached to the sides in a similar manner. The top plate of the crematory comprises four separable sections which are curved transversely, the outer edges having upturned flanges, and when these plates are connected they are adapted to fit within the side and end walls, resting upon projections attached to the upper plates of the side walls. The two rear plates used in making up the top have openings, above which and near the center are placed hoppers. The other plates have openings over which are placed chimneys, which are established adjacent to the corners near the front wall. No bottom plates are required, and the side walls rest directly upon the ground. Within the furnace is a longitudinal dividing wall of sheet iron, possessing recesses in which rest the inner journals of the upper grate bars. These are concave in cross section, so that when their concave portions are upward they form a series of pans in which the liquid

portion of the garbage is evaporated. Some distance from the front wall of the furnace, and attached to the longitudinal dividing wall, is a vertical plate which forms the rear wall of the ash-pit and serves as a support for the rear ends of grate-bars of ordinary pattern, which are supported anteriorly by the front wall. Running from the upper side of the vertical plate, so as to extend from the rear of the ash-pit and incline upward therefrom, is a corrugated iron plate, to the rear end of which is bolted a small curved sheet of metal extending to the rear wall.

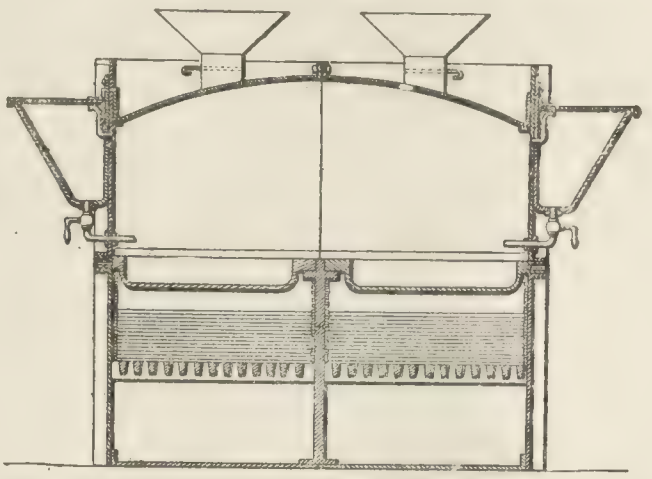


FIG. 179.—Transverse Section of Conley Camp Crematory.

The vertical walls below the grates, and above the grate-bars and the corrugated plate, are covered with asbestos, so as to protect the side plates from direct contact with the flame—and the longitudinal wall is similarly protected. The object of corrugating the plate transversely is to form a series of recesses which will retain a certain amount of the fluids which may fall from the upper grates, and such fluids and ashes serve to protect the plate from direct contact with the flames.

For evaporation of the fluid portion of the garbage, receptacles are bolted to the sides of the furnace above the evaporating grates, and these are provided with valved conduits which lead into the furnace above the evaporating grates. These receptacles are also provided with small pipes leading into the furnace to allow of the escape of the steam generated. For camp use the liquid and solid parts of the garbage should be separated; the solid parts being passed into the furnace through the doors above the grate-bars and also through the hoppers. Wood or other fuel is placed upon the lower grates, and when the fire is started the products of combustion will pass under and over the garbage, as indicated by the arrows in Fig. 180, and when the same is sufficiently dried one or more of the grates may be dumped, so that the dried garbage will serve as fuel for burning subsequent charges. As the garbage is heated, the grease and other like material is caught in the concave grate-bars and the liquid is evaporated; so that the concave grates not only serve as a series of evaporating-pans, but the liquid which they may contain will prevent the burning out of the grates. The fluids which have been separated from the garbage may be placed in the receptacles and fed into the furnace over the concave grates by the pipes provided. Each of the grates is provided with means for dumping, one independent

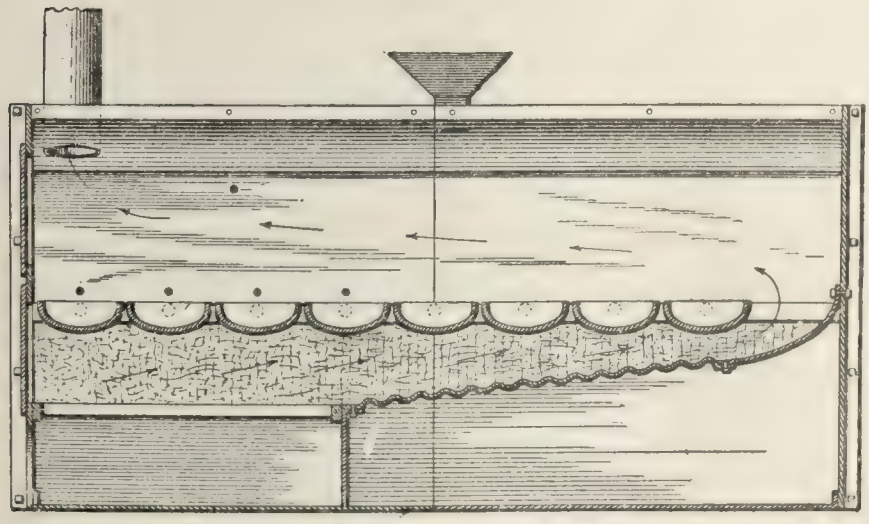


FIG. 180.—Longitudinal Section of Conley Camp Crematory.

of the other, so that the required amount of dried and heated garbage may be dumped either upon the deflecting-plate or upon the grate.

The metal plates constituting the sides, ends, top, and division-wall are completely covered on their inner sides with sheets of asbestos, which have an interposed wire netting or fabric; such sheets of fire-proof material being attached to the plates by staples.

With this furnace a comparatively small amount of wood or fuel is needed to dry out the first charge of garbage, and after the fire is started the garbage which is dried out serves as fuel for subsequent deposits. When the garbage in one of the grates has been dried, this grate can be dumped; and while maintained in a vertical position the products of combustion will pass around it between the grates adjacent. Thus should it at any time be desired to use only a few of the grates, those that are not required may be placed in a vertical position, so that the products of combustion will pass entirely around those in use.

By duplicating the construction on each side of the center of the furnace the garbage may be fed into the same; so that what is deposited on one set of concave grate-bars or receptacles, after having been dried out, may be dumped on the grates beneath and used as fuel for a subsequent charge. The products of combustion from the garbage on one of the sets of grates, as it is being consumed, will heat and dry out the garbage on the other set of concave grates, and by feeding the garbage alternately through the different hoppers it is used as fuel.

This crematory has been given a practical trial in the military service, and has proved to be an effective way of disposing of large quantities of garbage and camp offal. It can be set up by two men in four or five hours, and can be taken apart for transportation in much less time. One crematory will destroy the solid garbage for a brigade, and will evaporate fluids at the rate of 25 gallons per hour. Complete, its weight is only 900 to 1,000 pounds. But little fuel is required for its operation; and for the combustion of camp refuse, outside of excrement, it appears to be in all respects very satisfactory.

A slightly modified form of this crematory, 6 feet long, 3 feet wide and 33 inches high, has been mounted on trucks for convenience in consuming the garbage of a large camp. This is intended to collect the refuse from various stations and burn it on the spot or while in transit. It is capable of burning all the solid refuse for a brigade, but its evaporating power is somewhat less than that of the fixed apparatus. Its weight, without the trucks, is about 1,000 pounds. This crematory wagon is constructed with double walls around the furnace and also has a flooring of clay to diminish the loss of heat. An ash-pit is attached to the furnace just behind the rear axle. The smoke-stacks are hinged, so that they may be lowered to the top of the furnace during transportation.

The Smith portable crematory, of which a considerable number have been purchased for use at tropical stations, has a wider field of usefulness than the above, since it is designed to serve the combined purposes of a latrine and refuse crematory. The apparatus consists of a series of hoppers arranged in a circle about a central furnace. The urine and fæcal matter are received upon flat excreta plates, so inclined that the fluid parts flow toward the central fire-box and are subjected to constant drying. The

solid part of the excreta is from time to time pushed from beneath the hoppers to a space around the fire-pot, and when dried, can at any time be raked on the grate and burned. A large evaporating pan is placed above the fire for the reception of fluid and solid garbage. When dried sufficiently, the garbage pan is revolved by a crank and the contents are deposited on the grate, where it serves as fuel. As the garbage falls upon a grate above the fire, and not directly upon the fuel, there is no need of complete drying in the evaporator if extra heavy duty is required.

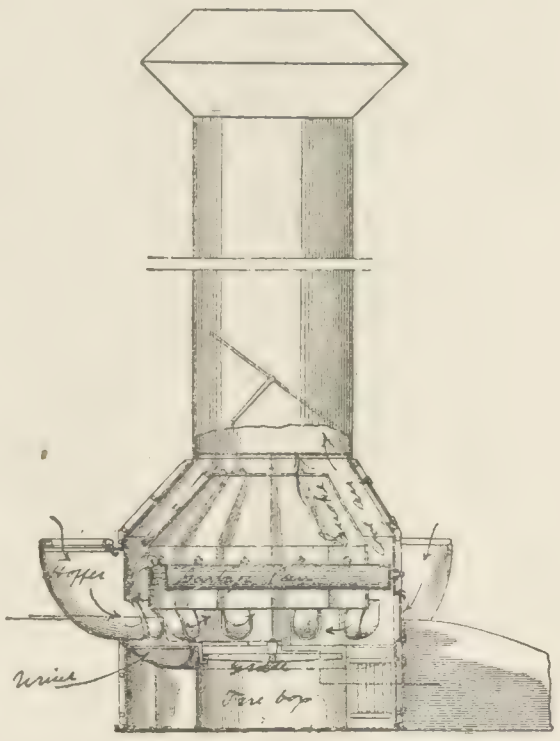


FIG. 181.—General Plan of the Smith Camp Crematory. The excreta hoppers are cut away in front to better show the detail.

An advantage possessed by this apparatus is the possibility of applying the flame immediately beneath the excreta plates, in order, if necessary, to hasten the drying and sterilization of the excreta as well as the adjacent parts of the apparatus. The whole plant may be sterilized at baking temperature if the draft is shut off at the seats. The fact that, owing to its peculiar construction, the central fire, while drying out the excreta and garbage, does not increase the temperature of the closet must be considered as another advantage, especially in hot climates. In operation, the apparatus is odorless. The ventilation is excellent, the downward draft through the hopper seats being sufficiently strong to prevent the egress of flies. This ventilation is secured by means of a pipe three feet in diameter, rising to a height of forty or more feet. The crematory is economical in action and capable of using as fuel almost any combustible material, such as wood, underbrush, straw, manure or soft coal, and the full capacity of urine, excreta and wet garbage can be desiccated and burned in the short space of three hours. This apparatus is transportable in the sense that it consists of a number of pieces of cast iron, joined together by bolts, which can be taken apart by ten men in five or six hours and re-erected in about the same time. The weight of an apparatus suitable for the needs of a company is, however, about 5,200 pounds, while a crematory sufficient for the needs of two companies would weigh about 7,000 pounds. The portability is therefore only

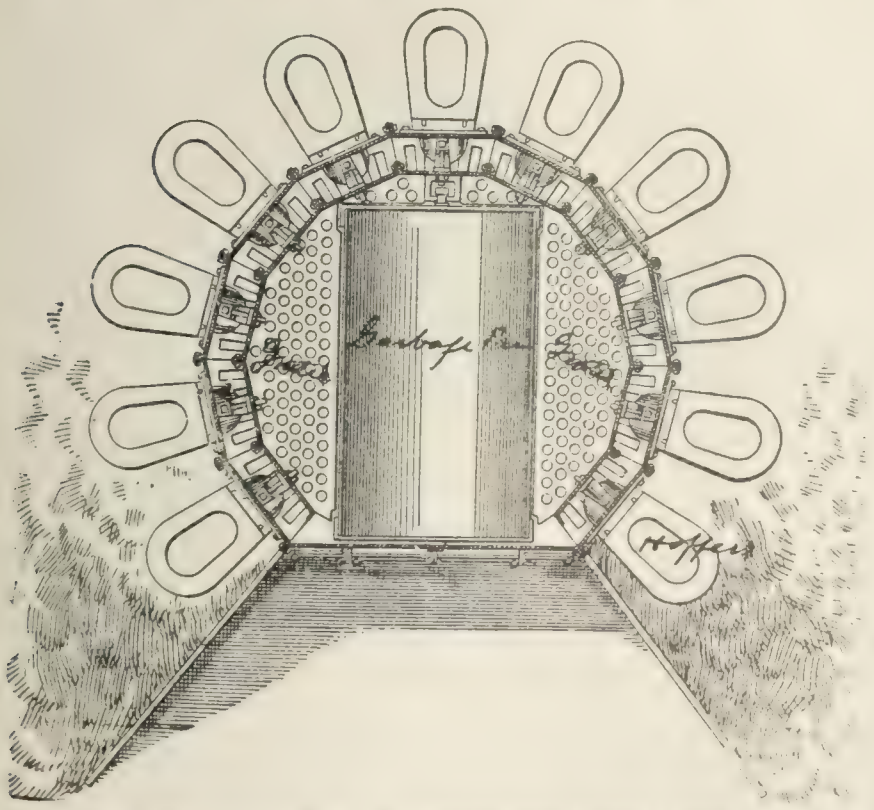


FIG. 182.—Plan of Smith Camp Crematory above Closet Hoppers.

such as would permit of its erection in more or less permanent camps, in which, after all, the need for such a crematory alone exists. This crematory, after exhaustive trials in the United States and Cuba, was strongly recommended by the several boards appointed to pass upon its merits, and appears satisfactorily to fulfill every purpose for which a camp crematory can be required.

Whatever be the methods employed for the reception, gathering and disposal of garbage and refuse, they should be under the direct supervision and control of a medical officer.

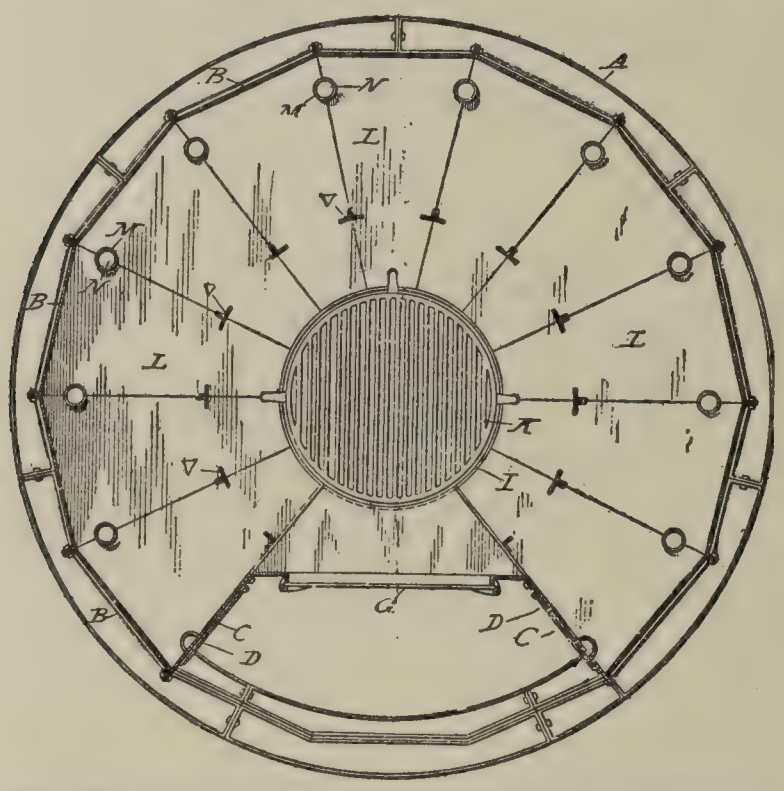


FIG. 183.—Horizontal Section of Smith Camp Crematory above the Excreta Plates.

Camp Police.—The term police, in the military service, implies the maintenance of cleanliness rather than of order, and for its proper execution the commanding officer is responsible. Company officers are required to maintain neatness and proper sanitary conditions within their respective organizations, and the police of the company area devolves upon the men of that command. In the regimental camp the work of general policing comes under the jurisdiction of the officer of the day, who has control of the prisoners and guard and is responsible to the commanding officer for the order and cleanliness of the camp. The general work of policing is performed by prisoners; but if these are insufficient, fatigue details are made from the command. With inexperienced troops, or with an incapable administration, the maintenance of proper police is rare; and under the former circumstances the more distasteful duties of camp police may advantageously be performed by civilians. The general police detail cleans up the regimental area, attends to the sinks and the disposal of refuse, and performs any other duties which may be necessary for the sanitation of the camp and the comfort of the men. To ensure the proper performance of this policing, inspections are required by regulations; monthly on the part the commanding officer and both daily and weekly by the company commander. The daily inspections are largely concerned with the sanitation and interior economy of the company—the weekly inspection being more in the nature of a military formality. This system ensures that any conditions unfavorably affecting the health or comfort of the command are promptly known to those individuals by whom their remedy can be accomplished. The maintenance of cleanliness of the camp requires systematic and constant watchfulness on the part of officers—and special regulations as to police, suited to existing conditions, can with advantage be promulgated from time to time.

Company streets should be swept daily, and the intervening spaces between huts or tents should be carefully policed. All refuse should be at

once removed, and nothing left behind to serve as a starting-point for further accumulation. The interior of habitations should be maintained in a state of scrupulous cleanliness, and should be swept or brushed out daily. Serviceable brooms for camp use can be made by tying together a number of small twigs of equal length—or the leafy branches of trees may be made to answer a similar purpose. If improvised bedsteads have been constructed, articles should not be allowed to collect under them; while if huts are occupied as quarters, special attention to the cleanliness of beams, shelves and other out-of-the-way places is required. All arms, blankets, and bedding should be daily exposed to the sunlight to prevent dampness, and the floor of the habitation should be cleared. Poles supported by forked uprights may be put up in suitable places, and are convenient for the drying and sunning of garments and bedding.

In camp, as well as in barracks, neatness and order are of great importance and their maintenance should be required. A want of care about the disposition of the equipment of the soldier would seem at first sight to be a military matter; but from a sanitary point of view it indicates a laxity as to detail which, if not corrected, will often result in carelessness as to cleanliness of the person and surroundings.

An accumulation of organic matter under the floors of tents or huts is a certain result of the absence of an efficient police; while if dirt floors are used, every care is necessary to limit their contamination to the minimum by the maintenance of cleanliness. In any but transient camps, food should under no circumstances be brought into tents. Special shelters should be provided for use at meals—or otherwise the remnants of food are certain to be scattered about the tent area and its vicinity. Dogs, in any number, should never be allowed in camp. In general, no contamination of the air space should be permitted, save that which necessarily depends upon occupancy. Before the abandonment of an old camp, its site should be as thoroughly policed as if its continued occupancy was contemplated.

An uncleanly summer camp is soon subjected to a plague of flies, which, in addition to its direct effect in promoting disease, becomes a serious source of irritation and annoyance to the command. To protect against such an invasion, or to limit its effects, due care should be given to the disposition of the excreta and refuse. As already stated, the latrine trenches should be enclosed and darkened and flies excluded; such an arrangement being insisted upon by the sanitary officer in any camp of comparative permanency. It is short-sighted economy which takes into consideration the small additional expense involved; yet certain commanding officers and quartermasters will be found, for this reason, to oppose such a suggestion. Lime, freely used, repels insect life—as does also crude petroleum. The latter, well sprinkled over an open latrine trench, is most valuable in keeping flies away from its contents. The low cost of crude petroleum, sixty to seventy-five cents per barrel, renders its employment not at all expensive.

The condition of the outskirts of the camp requires careful attention, and the removal of refuse from the camp area only to deposit it on the surface in the vicinity should never be permitted. The purlieus of the encampment should be kept as free from noxious material as the camping ground itself. Cleanliness should not be considered as accomplished, if the camp present a neat appearance while at the same time hidden foci of pos-

sible infection are permitted to exist. The sanitary index of the encampment is not to be found in the best cared-for huts or tents, but rather in those presenting conditions least desirable from such a standpoint. A single filthy habitation is a standing menace to the sanitary condition of the others.

Soil contamination in camps is only a question of time, and the length of time a camp site can be safely occupied by troops depends largely upon the efficiency of its police. If proper cleanliness be not maintained, and dangerous refuse be not removed, the frequent transfer of the camp itself to a fresh site becomes imperative. It should be remembered that the use of disinfectants in camp is entirely subordinate to a frequent change of site and an efficient police.

CHAPTER IX.

POSTS, BARRACKS, QUARTERS AND HOSPITALS.

THE general requirements for a healthful habitation are thus summed up by Parkes:

(1) A site dry and not malarious, and an aspect which gives light and cheerfulness.

(2) A condition of house construction which ensures perfect dryness of foundation, walls and roof.

(3) A system of ventilation which carries off all respiratory impurities.

(4) A pure supply and proper removal of water, by means of which the proper cleanliness of all parts of the habitation can be ensured.

(5) A system of immediate and perfect sewage removal, which renders it impossible that the air or water shall be contaminated from excreta. To this may be added:

(6) An arrangement for the sufficient and equable distribution of heat.

Location and Arrangement of Posts.—The same considerations of topography, soil, and exposure which have been discussed in connection with the location of camps, obviously apply with even greater force in the selection of sites for permanent posts and barracks. With camps, a bad site inadvertently chosen may be readily abandoned; but a post, once established in a locality of unhealthful character, is, from motives of economy, given up with reluctance. In the past it has often happened in our service, where military stations were injudiciously located or planned, that this was due to the fact that the position taken depended upon a chance combination of circumstances. Frequently the needs of the service required a location, originally occupied for temporary purposes only, to be permanently garrisoned; and thus from a camp or winter-quarters a military post was developed. Old buildings which had been hastily erected and roughly constructed for temporary shelter only, were usually retained in the permanent post to serve certain purposes and save labor. In many instances the post itself, thus brought into existence, was regarded as merely temporary, and no effort was made to drain, plan or beautify it. This method of developing a post has many obvious disadvantages; and it is in general far preferable to let any rough work which may have been performed go for nothing, and start fresh on a carefully selected site, with a well-defined plan from the outset. In the future, under more settled military conditions, any such hap-hazard methods of development as have obtained in the past will scarcely be necessary — and in all instances the opinion of a sanitary officer should be obtained with reference to the location and arrangement of a proposed post before its construction. This has not always been done in the past; and at many stations, in the

establishment of which this precaution was omitted, the sick rate—as was to be expected—has been unduly high.

In addition to the general requirements of a healthful site for habitations, as given elsewhere, the ground in the vicinity of barracks and quarters should usually be under-drained to a depth of six or eight feet. Statistics show that where the level of the ground water has been lowered, the health of the locality drained has been much improved. Buchanan found, in a large number of towns in England, that under-draining of the soil was followed by a marked decrease in the prevalence of tuberculosis. At Salisbury the mortality from this cause fell 39 per cent.; at Rugby 33 per cent., and at Worthing 36 per cent. The greater the number of drains, the better the result in retentive soils; but in gravel and free soils no more drains are required than will properly lower the ground water. As dry a site as possible should be selected; bearing in mind that damp soils are always insalubrious, and that it is a difficult and costly task to make an unwholesome place healthy. A safe rule to follow is to choose a site from which there is drainage and into which there is no drainage; this applying to sub-soil as well as surface water. Usually such conditions can be satisfied in the immediate vicinity of a point which it is desired to garrison. Made-ground should be avoided as sites for buildings unless the soil is known to be free from organic pollution, in which case the site may be healthy.

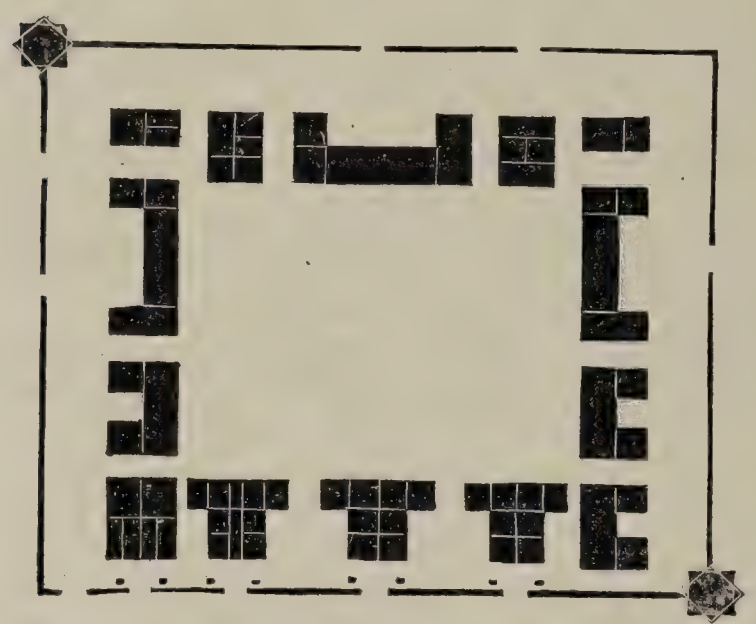


FIG. 184.—Ground Plan of Fort Ellis, Montana, Showing Old Method of Grouping the Buildings of a Post.

Posts should preferably be located away from the immediate vicinity of large cities. This usually gives more free space and purer air, while at the same time it limits the various temptations to vice which beset the soldier. In towns, density of population has a direct influence on the mortality of the inhabitants, and this rule appears to hold good also for the military service. Buildings should therefore not be crowded together; but on the other hand, too much ground in a post is undesirable, as it increases the difficulties of drainage and police. Buildings are properly lighted, aired, and sunned if no two are placed nearer to each other than twice the height of the ridge of the taller building.

In their aspect, long barrack buildings, in temperate climates, should face the east to receive the full benefit of the sunshine, and give it access to both the long sides of the structure. It is desirable, also, that they be broadside to the prevailing wind; and if built on a slope that they should be end-on to the side of the hill. In their arrangement, no special disposition is essential from a sanitary standpoint so long as the barracks do not interfere with each other in respect to the free sweep of the wind. In the British army the pavilion barracks are placed in parallel lines.

In our own service, posts were long constructed on the four sides of a

square, with a central parade—as is well shown in the accompanying plan of Fort Ellis. This quasi-defensive arrangement, a relic of the old stockaded posts necessary in the days of early Indian warfare, is no



FIG. 185.—Post of Modern Construction, Showing Arrangement of Buildings. 1, Commanding officer's quarters; 2, officers' quarters; 3, guard-house; 4, barracks; 5, band quarters; 6, saddler shops; 7, hospital; 8, non-commissioned staff quarters; 9, cavalry drill-hall; 10, cavalry stables; 11, post exchange; 12, bakery; 13, store-house; 14, store-house; 15, scale-house; 16, forage-house; 17, shops, 18, ordnance; 19, fuel shed; 20, oil-house; 21, magazine; 22, water tower.

longer required, and there is now no reason why a compulsory external form should govern internal arrangement. Posts built on this plan are always unsightly from the exterior, some of the buildings are necessarily badly oriented, and full advantage of the surface configuration of the

ground is not attained. In general, the arrangement of the buildings, after reasonable convenience of administration is secured, should be varied in their relations according to the nature of the locality selected. This plan has been followed with advantage in the establishment of a number of posts of recent construction; among them being Forts Sheridan and Ethan Allen, plans of which are given in the accompanying illustrations.



FIG. 186.—Plan of Fort Sheridan, Illinois. 1, Officers' quarters; 2, non-commissioned staff quarters; 3, chapel; 4, barracks; 5, mess-hall; 6, infantry drill-hall; 7, fire station; 8, post exchange; 9, gun shed; 10, guard house; 11, ordnance store-house; 12, bakery; 13, storehouse; 14, cold storage; 15, shops; 16, quartermaster's stable; 17, wagon shed; 18, stable guard house; 19, forage storehouse; 20, cavalry stables; 21, stable sergeant and saddler; 22, cavalry guard house; 23, cavalry drill-hall; 24, magazine; 25, bachelor officers' quarters and mess.

Arrangement and Plans of Barracks.—While military barracks appear to have been employed in Rome and Constantinople about the time of the Christian era, their use was shortly afterward discontinued. During the Middle Ages the armies were comparatively small; and standing forces, as organized bodies, were not maintained. Where the shelter of soldiers became necessary, they were quartered on the civil population—much to the detriment of all concerned. During the feudal period, bands of armed retainers were sheltered by the nobles to whom they owed allegiance and afforded protection, but no large bodies of troops were maintained on a permanent footing. About two centuries ago, however, the

necessity for constant military preparedness caused the establishment of large permanent forces; while the more rigorous standard of discipline introduced rendered it still further necessary to bring soldiers together for habitation and control.

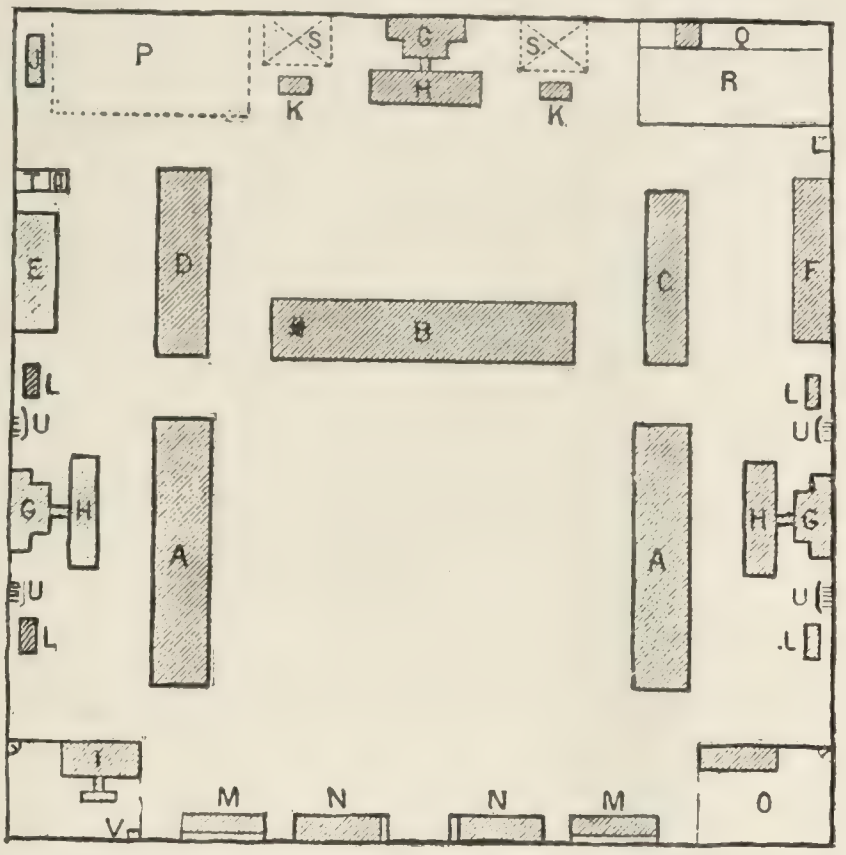


FIG. 187.—Modern Arrangement of Buildings in a Garrison Station of Infantry, French Army. *A*, *B*, barracks; *C*, canteen; *D*, store-house; *E*, stables; *G*, kitchens; *H*, mess-halls; *I*, infirmary; *K*, bath-houses; *L*, latrines; *U*, urinals; *M*, guard houses.

The barracks at first erected, as devised by Vauban, were large, and planned with special reference to economy of space. They were of several stories in height, and were built around the four sides of a square court-yard; entrance being had at the corners. They were imposing in appearance and capable of excellent use for defence. The men were kept well in hand, communication by the central corridors and inside porches was easy, and the enclosed court was admirable for military exercises. From the point of hygiene, however, their defects were both numerous and grave; the central court-yard was damp, not exposed to air currents, and badly sunned; two sides of the barrack necessarily had an undesirable exposure; the latrines, kitchens, hospital and other accessory institutions were in the same building, and with mounted troops the horses were stabled on the ground floor of the barracks—the last condition not being entirely done away with at the present time in the barracks of certain armies. Some of the barracks built on this plan were enormous, several accommodating 3,500 men, and one, at Lyons, holding 5,000 men. An epidemic once started in a barrack of this size and character could not fail to be severe, and buildings of such nature were soon justly regarded as unhealthful. In spite of this fact, square enclosed barracks have from time to time been erected in the French, German and Italian services, and such were recently built for the accommodation of Spanish troops in Cuba and other colonies.

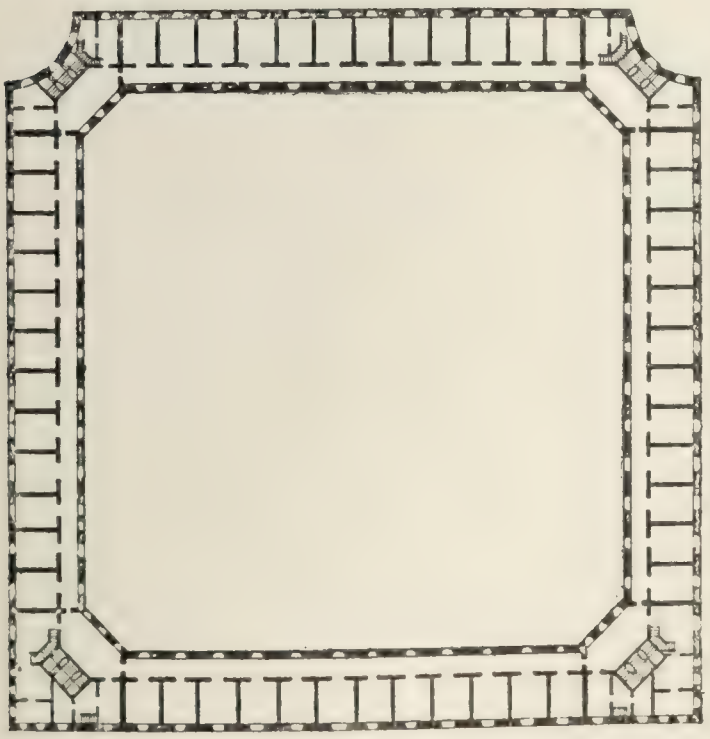


FIG. 188.—Ground Plan of Original Style of Barracks, as Devised by Vauban. (After Putzeys.)

A modification of the original type of Vauban barrack consisted in locating four linear, but detached, buildings in the form of a square; leaving the corners open

to permit of the circulation of air through the court-yard. In these barracks the galleries were left off and greater attention was given to ventilation—as a result they proved much more healthful.

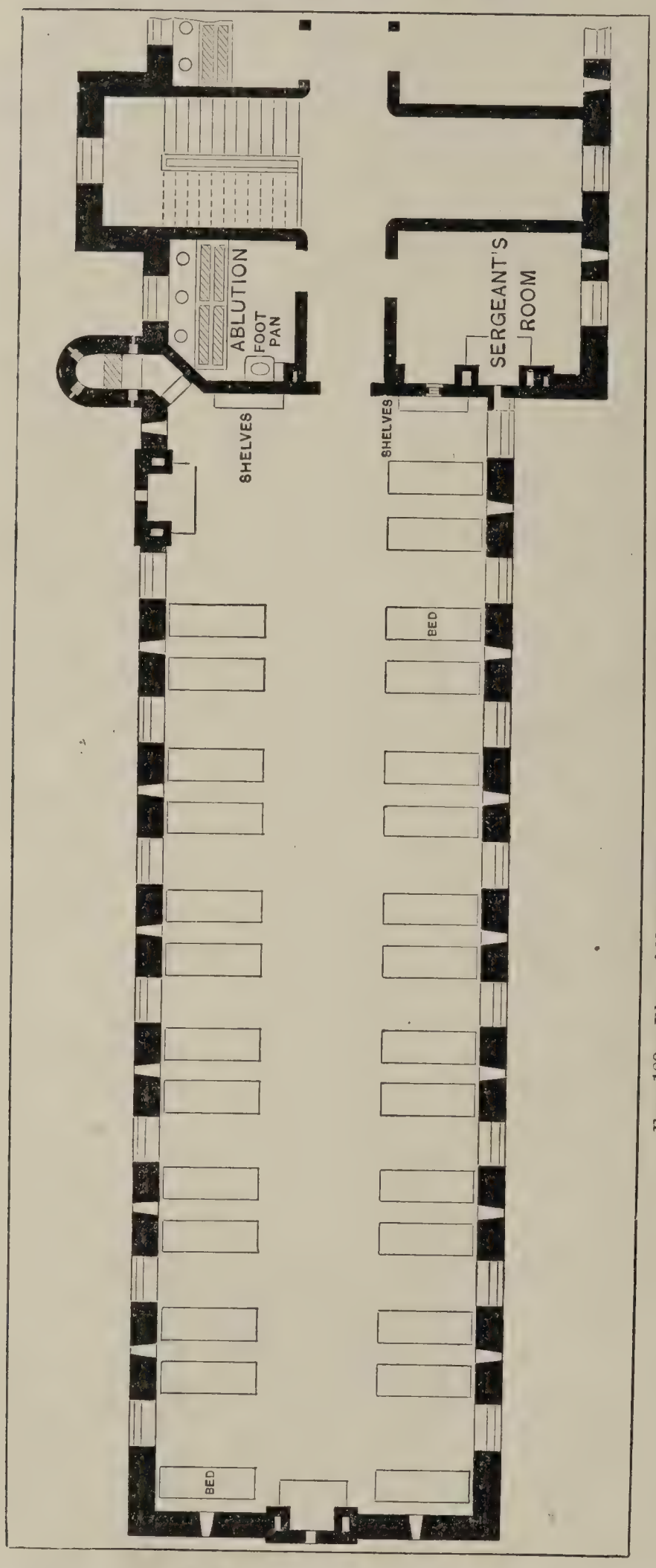


FIG. 189.—Plan of New Model Barracks Adopted in the British Army.

To avoid the disadvantages of an interior court and the bad orientation of a part of the barracks, about the middle of the present century a linear type of barrack was introduced; this plan being much used abroad. It was later found to be inconvenient from the necessity of having the kitchens, lavatories and latrines in the main building—as it was originally planned—and these accessories were then put in additions extending from each wing. While very convenient for the double or single company barracks used in our own service, this latter arrangement also proved unsatisfactory in foreign armies, in which a large number of men are habitually quartered together. A linear plan of barrack was then resorted to, containing merely the quarters of the men, while the kitchen, latrines and lavatories were put in detached buildings. This, in general, is the plan at present employed in most modern barracks abroad; but the barrack buildings used in the British service are chiefly pavilions, having a capacity of but one company, while on the continent these buildings are large and substantial structures. In the German army, the newer type of barrack has accommodations for a battalion.

In the British service, a revolution in barrack construction occurred as a result of the investigation of conditions in that army immediately after the Crimean War, an example which other foreign nations have strangely been somewhat slow to follow. During this investigation, all the barracks in the United Kingdom were examined and many were found very defective. The death rate among troops in barracks at that time was 17.11 per thousand strength; while among the civil male population between the ages of twenty and forty it was 9.8 per thousand, or about one-half. The beneficial results of improved barrack construction and management were speedily shown in the greatly diminished mortality and sickness among the men; and in 1876 the mortality among troops had been reduced to nearly 2 per thousand less than that of the military class in civil life, while the amount of hospital accommodation necessary for troops was decreased from 10 to 6 per cent. The modern British barrack is most simple in its construction, being of one or two stories in height and containing on each floor a single squad-room, sergeant's room, lavatory and night-urinal. For a regiment of infantry, thirty such barrack units are required. Each squad-room is 77 feet long, 21 feet wide, and $10\frac{1}{2}$ feet high; affording 600 cubic feet of air space and 57 feet of superficies to each man. Five square feet of window space are allowed per capita; measurements being taken within the inside bead of each frame. The beds are placed in pairs between the windows. These buildings, when placed longitudinally in parallel rows, are required to have a clear distance between them equal to at least twice the height from the ground to the eaves.

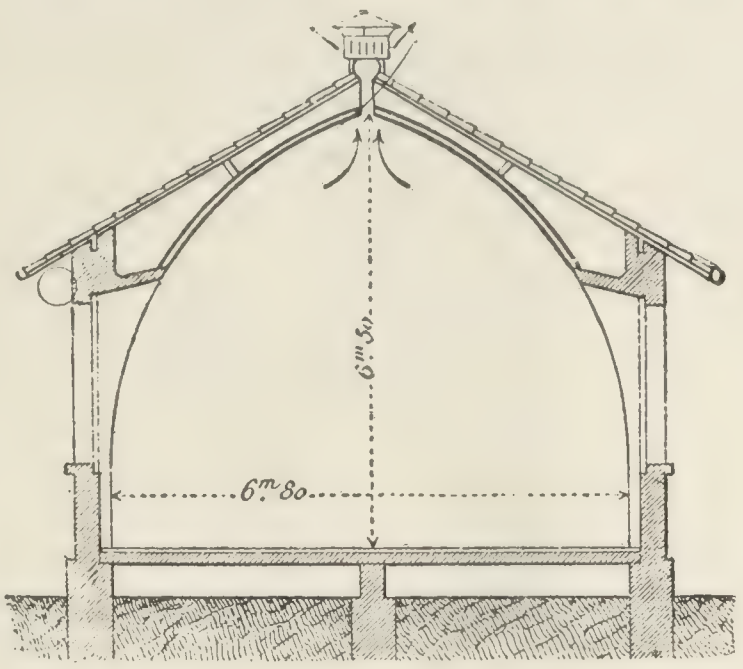


FIG. 190.—Transverse Section of Tollet's Pavilion Barrack, as Used in the French Army.

In the French army, a modified form of the English pavilion barrack, devised by Tollet, has been tried in the garrison at Bourges and has given much satisfaction; in spite of which, apparently from financial reasons, it has not been generally adopted in the French service. Such barracks are built of brick and iron, and have a special arrangement of the roof and inner wall designed to prevent extremes of temperature and to facilitate ventilation. The outer walls are built of solid brick, the inner of hollow

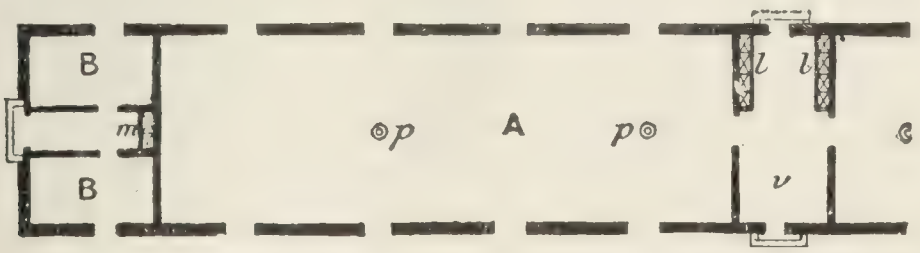


FIG. 191.—Ground Plan of Tollet's Pavilion Barrack, as Used in the French Army.

brick; between the two being an air space of about five inches thickness. The floor is covered with cement or bitumen and is raised about two feet from the ground; the latter, under the building, being given a coating of concrete. The pavilion is extremely simple in detail, as shown in Fig. 191. The air space per man, allowed in these barracks, is 775 cubic feet.

This pavilion system of barracking troops is regarded with much favor by foreign sanitary officers. In services which still use larger and more solid barrack buildings under ordinary circumstances, the pavilion system has been adopted for the permanent camps of instruction already noted.

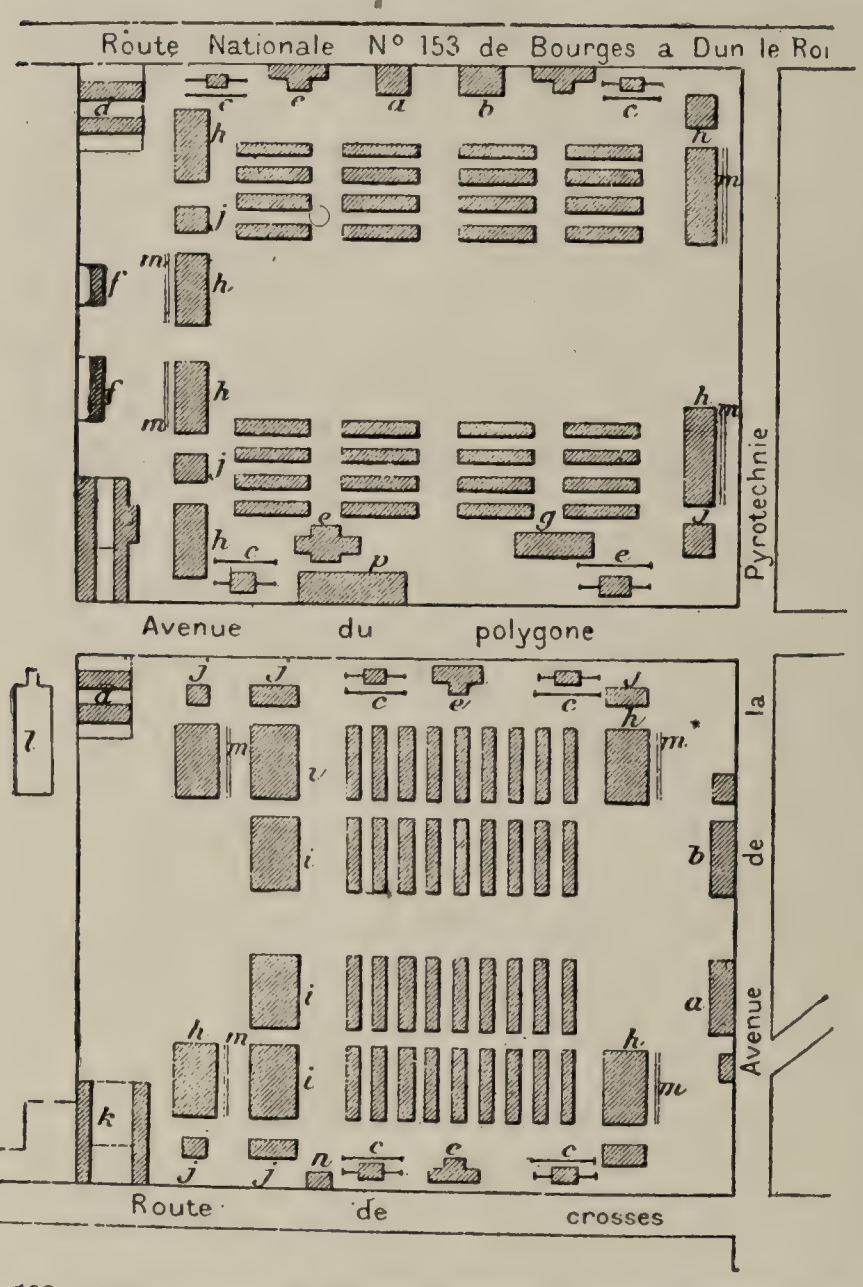


FIG. 192.—Arrangement of French Barracks, Pavilion System, at Bourges. *a*, *b*, Entrance pavilion; *c*, kitchens; *d*, infirmary; *e*, latrines; *f*, guard house; *g*, canteen; *h*, stables; *n*, lavatory.

In our own service the character of accommodations for troops varies with the post. The material entering into the construction of barracks has largely depended upon availability; while the plans of the buildings, in many cases, have had particular relation to existing military necessity and considerations of economy. While some barracks are well built and are excellent in character and condition, others were hastily constructed, especially at western stations, from poor material and without proper reference to ventilation or other sanitary requirements. After several decades of use a number of these buildings have become unfitted for occupation; and from such stations there are constant complaints of overcrowding, defective ventilation, bad construction, insufficient means of heating, undrained sites, leaky roofs and general dilapidation. In some instances, needed repairs and alterations have not been made, on the supposition that the post would soon be abandoned; yet the latter has sometimes been continued, from year to year, for considerable periods. A steady improvement in the sheltering of troops, however, has gone on during the past ten years, partly by the construction of new posts but more especially by the abandonment of old ones; as many as a dozen stations having been discontinued in a single year. At present, as a general rule, the barrack buildings of our army may be considered to be in passable sanitary condition—being comfortable,

clean and fairly well ventilated. There are nevertheless certain exceptions to this rule, and it is undeniably true that the habitations of our soldiers have not in the past received the attention which they deserved. With respect to barracks, equally with other matters, a false economy has considered many things as luxuries for soldiers in garrison—and hence to be gone without—which are regarded as necessities in civil life. This attitude is much to be deplored, particularly since the military spirit strongly tends to limit complaint and criticism on the part of those

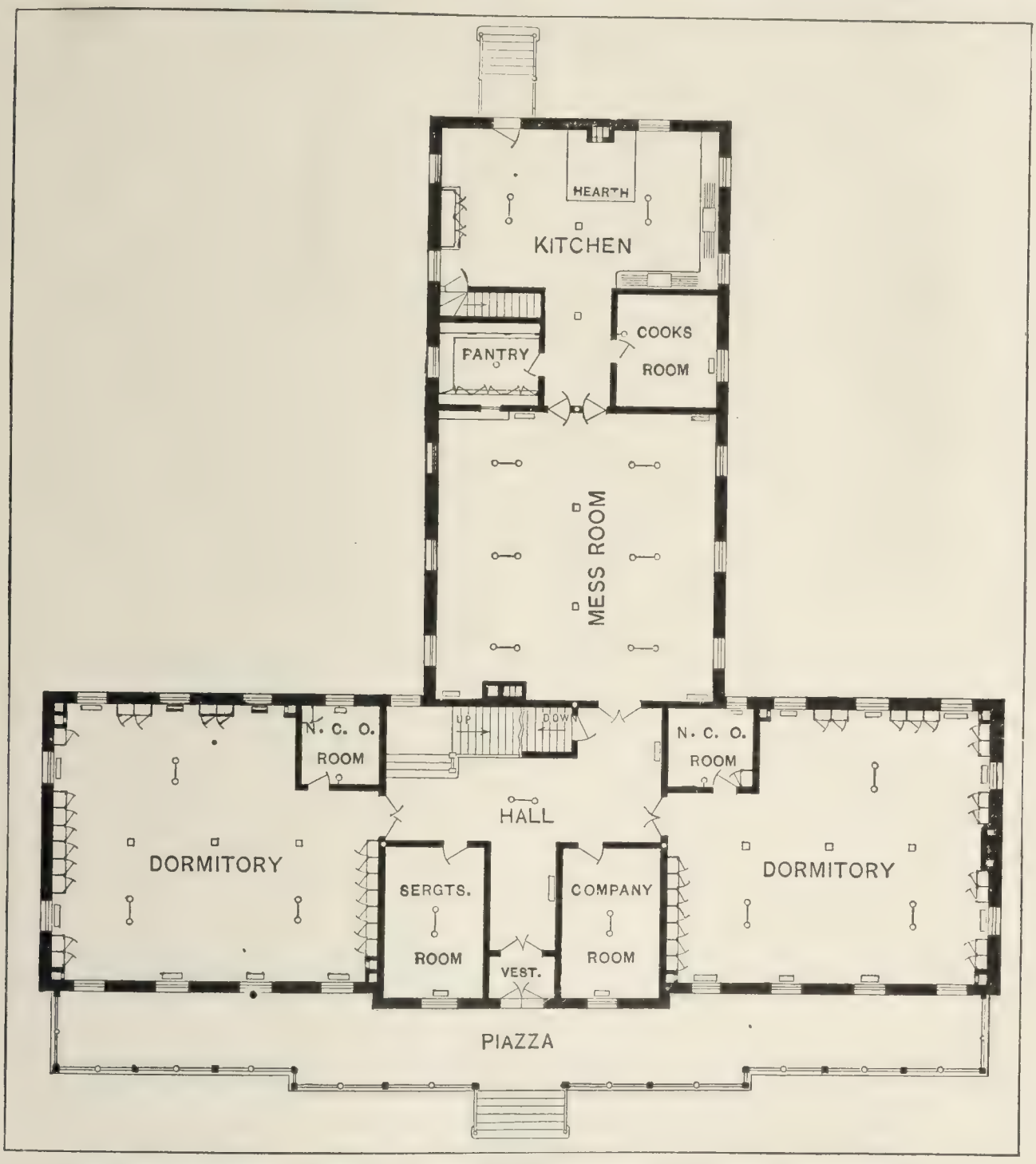


FIG. 193.—First Floor Plan of Artillery Barrack for One Hundred and Twenty Men.

most concerned, and favors unquestioning acceptance of what may be officially provided, regardless of character or quality. Economy was formerly long too much of a watchword among those having the supply of our army in charge; they apparently overlooking the fact that the training of a soldier necessarily represents a large financial outlay, and that below a certain point, irrespective of humanitarian considerations, diminution in expense of maintenance means an increased and disproportionate wastefulness of life, health and efficiency. In this connection it may be added, also, that in view of past mistakes in construction no buildings intended for occupancy by troops should be erected by the construction

department until the plans have been examined and approved by a sanitary expert. It may be accepted as a general rule that where barracks are not of the best character the sick-rate will be proportionately high.

The habitations which have been erected within the past few years for the shelter of our troops are excellent in their internal arrangements, and the later plans leave but little to be desired. The recent change from double sets of barracks to those accommodating a single company is much

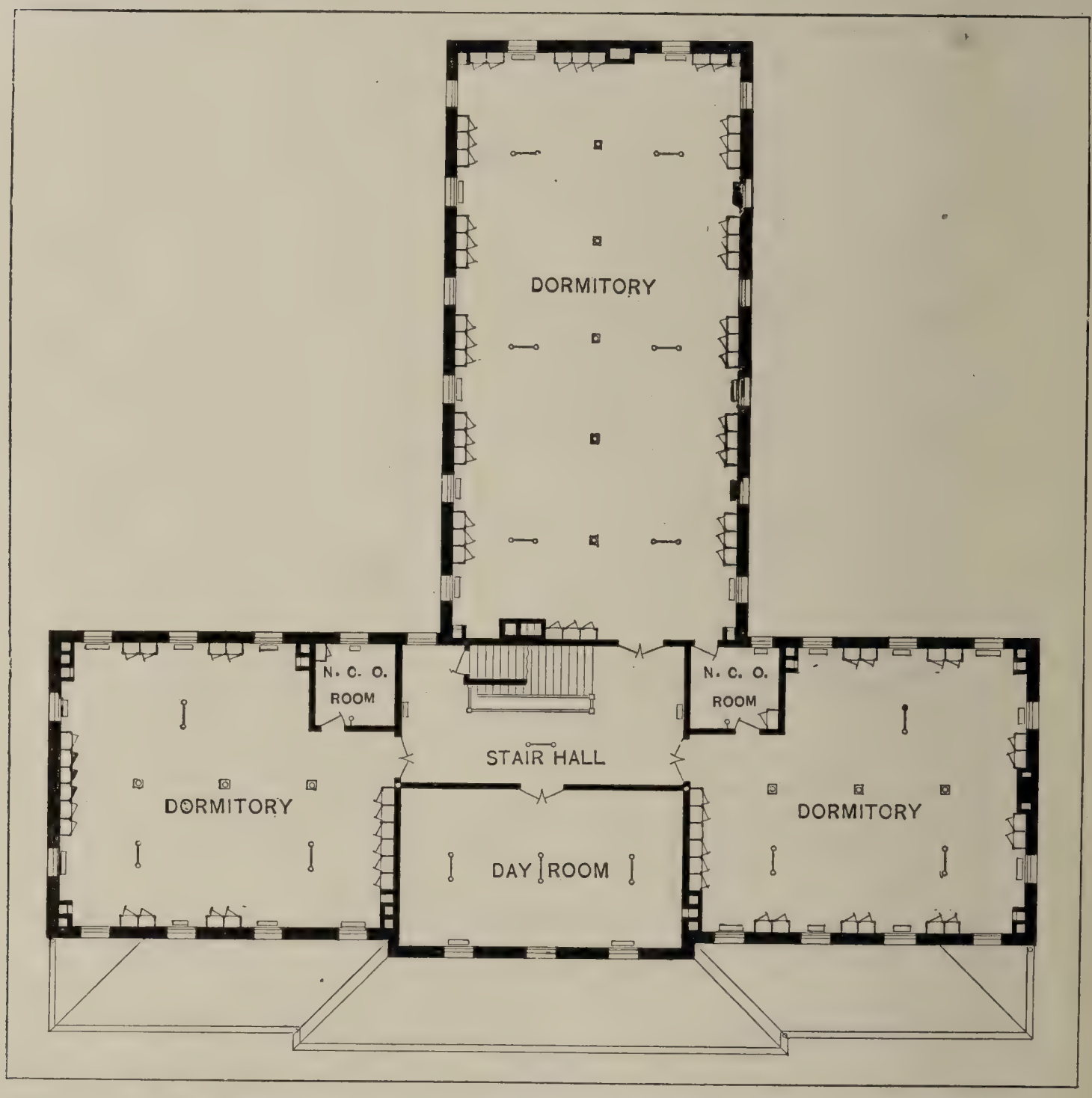


FIG. 194.- -Second Floor Plan of Artillery Barrack for One Huudred and Twenty Men.

to be commended. The general plan of these new barracks is a main building with one or two wings. The former arrangement is preferable, as being more compact, convenient and better exposed to sun and air. The new artillery one-company barrack, capable of holding 120 men, lately adopted in our service, is far superior to anything of the kind provided in foreign armies. This barrack, however, like nearly all those lately erected, has the lavatory and latrine in the main building on the basement floor. Although these fixtures are so located as to be exposed to light and air on three sides, yet their location in the main building at all is to be deprecated. They are best placed in a detached structure, reached by a covered

way for shelter in stormy weather. The general arrangement of the building, however, is admirable from the standpoint both of hygiene and convenience. The central hallway affords great assistance in ventilation. The 1899 plan of barrack for 100 men, with two wings, is far less desirably

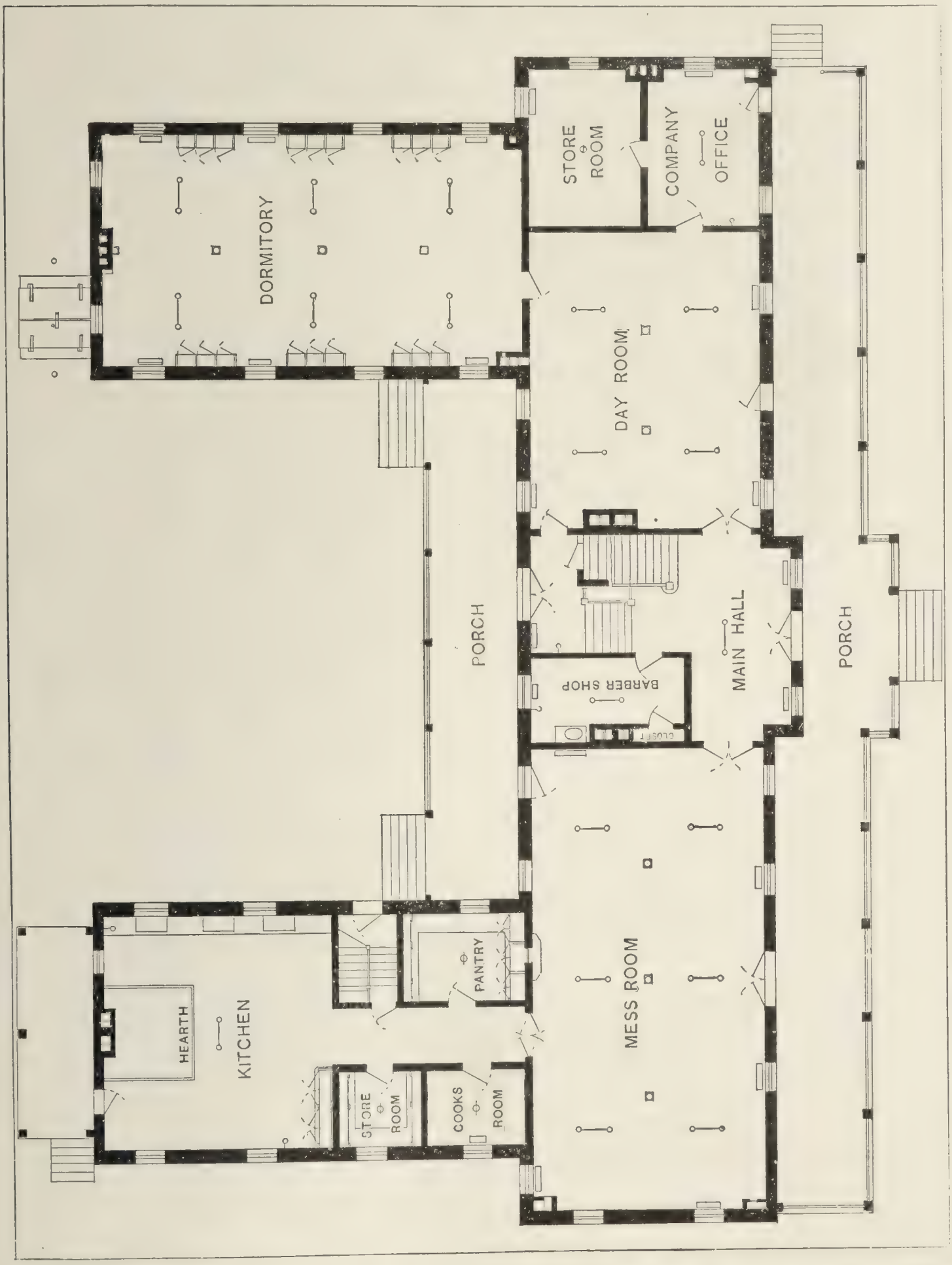


FIG. 195.—First Floor Plan of One Company Barrack, Having Accommodations for One Hundred Men.

arranged. The latrine and lavatory are beneath the mess-room, and the squad-room on the first floor can be reached only by passing through the day-room. While the squad-rooms on the upper floor have the advantage of containing but two rows of beds, they are much too large and shelter nearly twice as many men as should be placed in a single room. Where

such large squad-rooms are employed, the men occupying the bunks nearest the door are at a great disadvantage from the constant passing in and out. The men themselves also much prefer smaller squad-rooms, through the greater opportunity for comparative privacy and more congenial association

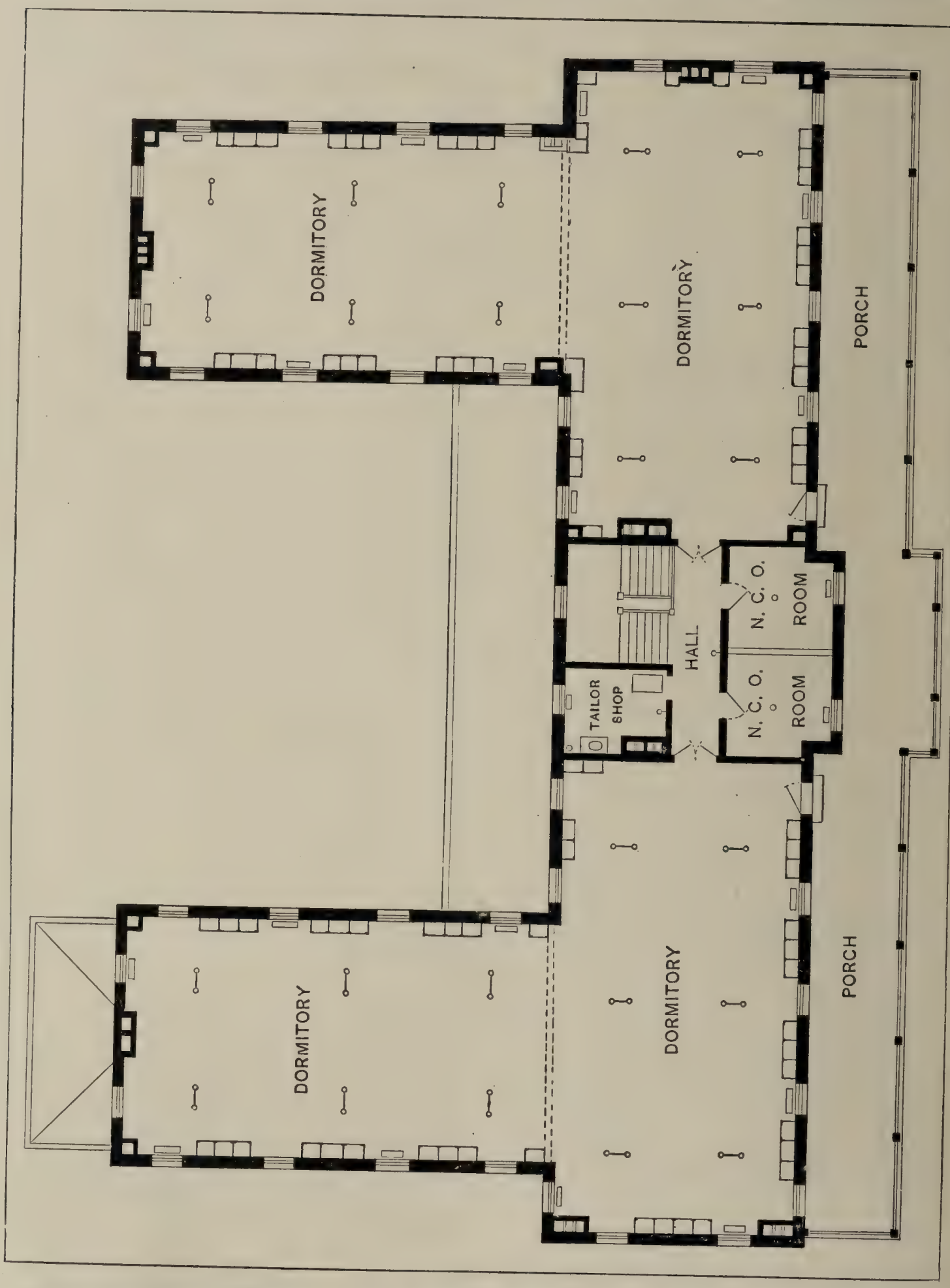


FIG. 196.—Second Floor Plan of One Company Barrack, Having Accommodations for One Hundred Men.

which is thus afforded. In general, squad-rooms should be sufficient to accommodate not more than twenty to twenty-four men.

General Principles of Barrack Construction.—In considering the construction of barracks, only those points which have a well-recognized influence upon the health and welfare of their occupants will be discussed;

nor can these, in a work of this character, be gone into in detail. Barrack construction is a subject of such magnitude and importance that to treat it fully in all its phases would require a special volume.

The barracks now being erected in our service have walls of brick, stone or wood. In a few of the old posts, log barracks or those made of adobe are still in use. The material of which barracks are built is not, however, a matter of small importance. Walls should be non-conductors of heat and cold; and the substances of which they are made should be as carefully chosen as those for clothing, which serves a similar purpose with reference to the individual. Bricks are undoubtedly superior to all other materials for barrack construction—in every part of the country and under all circumstances. They are light, cheap, readily made, easily handled and durable. They are very retentive of heat, from their porosity, in the absence of wind; but this very porosity becomes a fault in heavy storms, when air and moisture may be forced through them. In fact, so much is this the case that it is desirable, in all brick walls, to make these of sufficient thickness to include a layer of mortar. Bricks absorb water readily and hence should not come in direct contact with the soil; an ordinary brick is capable of taking up about one-sixth of its weight of water, though very hard bricks take up less. For partition walls, bricks are excellent. Stone walls have the advantage of strength, durability and sightliness; but are porous and absorbent of water, though less so than brick. Galton showed that, as regards heat, the conductibility of marble was twice that of freestone, four times that of glass, six times that of brick masonry and more than seven times that of plaster. Experiments made by Putzeys gave similar results. It is therefore evident that the Spanish style of building—brick walls with stucco outside finish—is admirable not only for hot but cold climates. A frame wooden building is, in general, merely a cheap substitute for something better, and it is to be regretted that buildings of such material are being erected for the shelter of troops in garrison. They are comparatively cold in winter and hot in summer, and are very combustible and liable to deterioration. Logs will probably be no longer used for barrack walls except for small isolated stations in Alaska. When used for such a purpose, they should be peeled and squared, for round logs and chinking are a poor dependence. Adobe walls may be used in regions where there is little rain. Buildings constructed of this material are warm in winter and cool in summer. They are very absorbent and soon become contaminated with organic matter; and if there is much sand in the dirt from which they are made, insects are sure to work into them.

Cellars usually add much to the healthfulness of a barrack, but the level of the ground water should lie at least four feet below the cellar floor and the latter should be rendered impermeable to moisture and ground air. In addition, the cellar must be well ventilated. In cellars which are not floored with some impermeable material, the ground air gains ready entrance—being forced upward by a rise in the ground water or drawn up by aspiration into heated dwellings. In buildings without cellars the air is apt to be damp and musty, but a damp cellar is worse from a sanitary standpoint than none at all. Under certain conditions the under-draining of cellars may be necessary, but where this is actually required the site is

undesirable. To best prevent dampness and the rise of ground air in cellars, a layer of clay about one foot in thickness should be spread over the bottom of the excavation, and this should be covered with a layer of concrete, while a coating of asphaltum is added over all. This method, however, is somewhat expensive, and in our new barracks reliance is had on a single layer of concrete four inches in thickness. In damp soils this is certainly insufficient. Barracks without cellars should be elevated sufficiently above the ground to permit of ready inspection and policing of the space underneath, without the necessity of taking up the floors. This space should be well ventilated and should have a flooring of concrete. The latter requirement is rarely carried out in our service, in spite of its importance.

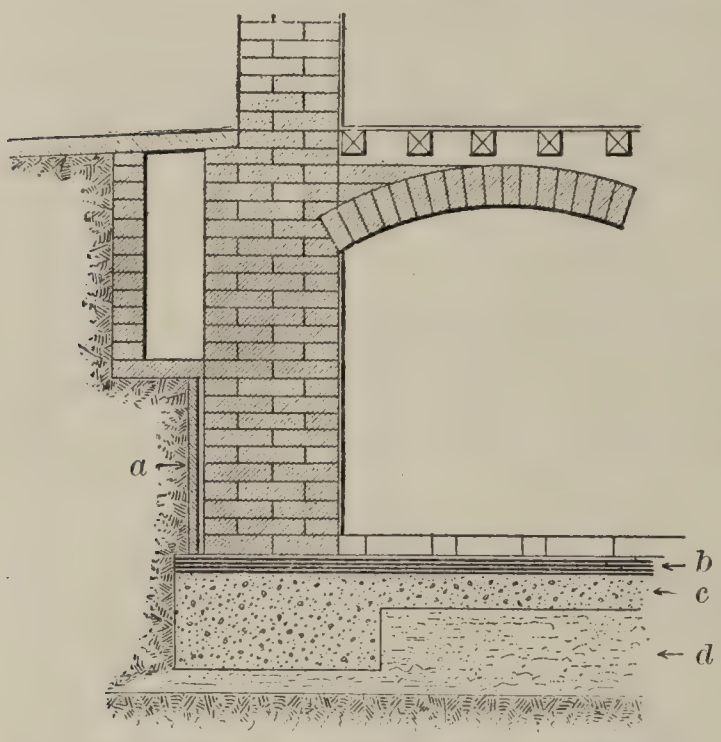


FIG. 197.—Method of Flooring Cellars to Prevent Dampness. *a*, Disconnected air-space lined with cement; *b*, asphalt; *c*, concrete; *d*, clay.

Foundations should be sufficiently solid and deep enough in the ground to give strength to the building. Where the ground is soft, or a solid foundation cannot be reached, the walls should be on a platform of at least four times their breadth. For this purpose concrete foundations are far preferable to those of stone, since they prevent moisture from rising by capillarity from the ground into the walls and thus rendering them permanently damp. The base of the walls should be expanded into footings; the lowest course of which should be twice the breadth of the walls, while their height should not be less than two-thirds of the wall thickness.

It is of great importance that the portion of the walls below the surface of the ground should be free from dampness. In our own service the effort is made to accomplish this by coating the outside of the wall with cement plaster, filling in the excavation outside the walls with stone filling, and under-draining below the foundation level. A better method, much used in England, consists in exposing the lower walls to the air by excavating the earth around them to the level of the foundation. This excavated space is walled on the outer side and under-drained; but unless protected by gratings or railings such excavations are inconvenient and a source of danger. Sometimes the surrounding air-space is made very narrow, and merely serves to prevent the main wall from taking up moisture by capillarity. Another method calls for the isolation of the wall by a broad air-space going several feet below the surface, the lower portion of the wall being prevented from absorbing moisture by an outside layer of cement or asphalt and sometimes by a narrow air-space. The part of the wall below the ground is built double in some foreign barracks. The outside portion is cut off from the inner wall by an air chamber, while moisture is prevented from rising into this inner wall by damp-proof courses. Asphalt plates, fastened together by heat, are strongly recom-

mended by Putzeys for protecting ground walls and cellars from soil moisture.

Walls above ground draw much moisture from the portions below the surface, unless special measures of prevention are taken. These usually consist in inserting damp-proof courses in the walls about six inches above the ground; these courses consisting of any suitable material impervious to water. Usually slates, embedded in hydraulic cement, are employed; sometimes sheet-lead is used, or hollow tiles or perforated vitrified brick. On internal walls the damp-proof courses are usually laid at the level of the concrete flooring. Above ground, also, walls take up considerable moisture. Against such dampness hollow external walls are the best protection. These walls consist of two thicknesses separated by an air space two or three inches in width; better located nearer the external than the internal face of the wall and extending completely around the building, including the corners. These two thicknesses should be bonded together with iron, for bonding of brick readily transmits moisture by capillarity. A damp-proof course is needed at the top of exposed walls, such as parapets and chimneys, to prevent storm water from soaking downward through the masonry. This is usually provided by finishing the top with stone and letting it project an inch or two over the side; or else having a damp-proof course of slate laid in the masonry at its junction with the roof. Many water-repellent combinations for coating the outside of walls have been proposed, but ordinary paint is very efficacious for this purpose. Where double walls are built, no other measures for securing dryness are, however, required. In the construction of our barracks solid walls are used, the lathing and plastering being furred out two inches on the inner side. This arrangement does not by any means give the best results as regards dryness of walls, but is cheaper. Dampness in walls greatly favors conductibility as regards heat, as well as having a relationship to the development of micro-organisms. The subject has therefore both an economical and sanitary importance, since damp barracks require an additional expense for heating and favor catarrhal and rheumatic affections and tuberculosis. The construction of walls also has a strong influence upon conductibility

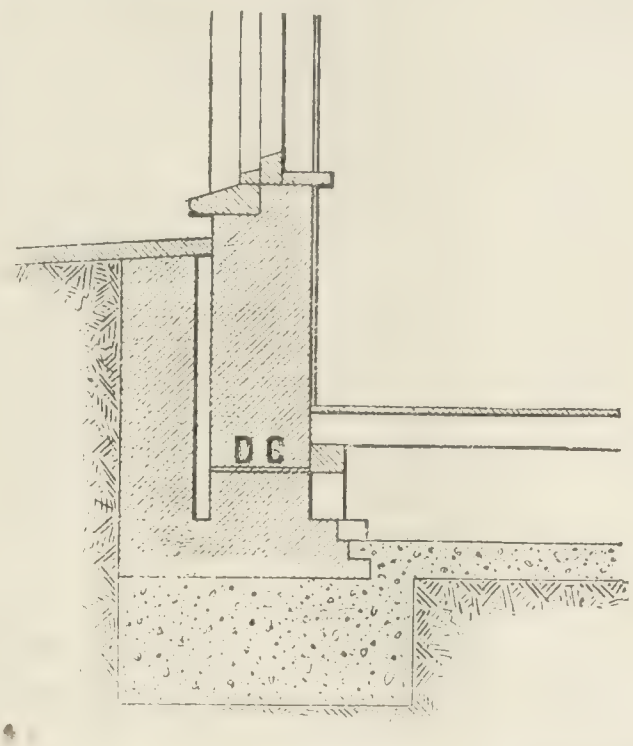


FIG. 198.—Method of Preventing Dampness of Walls. Letters *D C* denote location of damp-proof course.

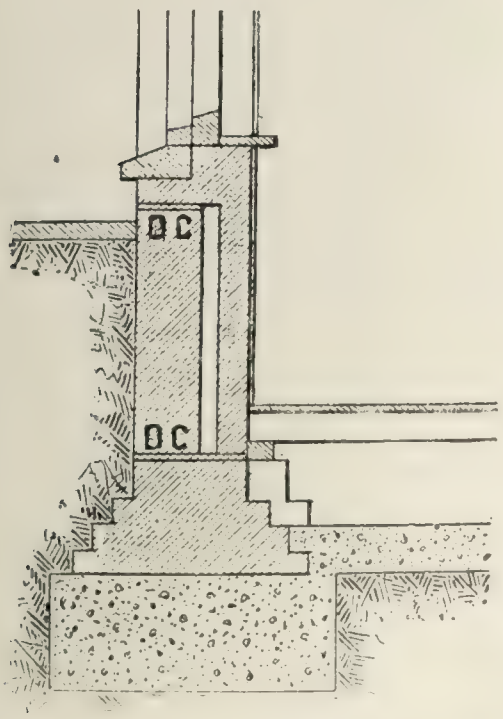


FIG. 199.—Method of Preventing Dampness of Walls. Letters *D C* denote location of damp-proof courses.

of heat, and with equal thicknesses a hollow wall transmits heat much more slowly than if solid. It is true that the construction of double walls implies a slightly greater original outlay; but this is ultimately much more than saved by resulting economy in heating, and it is important to remember that in cold climates proper ventilation and sufficient warmth cannot be combined with undue cheapness of construction. This point is emphasized by Carpenter, who gives the following figures for the amount of heat, expressed in British heat units, passing through solid and hollow walls; per square foot of area, per degree difference in temperature and per hour:

Thickness of wall in inches.	Single wall, brick or stone.	Wall with air space, brick or stone.	Thickness of wall in inches.	Single wall, brick or stone.	Wall with air space, brick or stone.
4	0.43	0.36	18	0.26	0.19
8	.37	.30	20	.25	.18
12	.32	.25	24	.24	.17
16	.28	.21	28	.22	.15

In winter, the air of the non-conducting space between walls should be confined, so as to limit the convection of heat by air currents. In summer or hot climates there should be some means of escape for the heated air, especially at night, and it is advisable to make openings above and below which can be shut during the day, or when low temperatures prevail. With single thick walls, in cool weather, the layers of air which come in contact with them are rapidly cooled down, with resulting condensation of their moisture and dampness of the room. In general, the thickness of barrack walls is determined by the size and height of the building rather than other considerations. Very thin walls do not properly protect against heat and cold, but unnecessarily thick masonry unduly increases the cost of the structure.

No wood-work should be placed in a barrack except where absolutely necessary for carrying the floors or roof, or fixing the fitments of the building. In the German barracks of recent construction no wood enters into the walls. Where wood is used, it should be so arranged that its shrinkage or decay will not affect the strength of the wall, and where the timbers receive support they should rest on stone templates with space for ventilation around them. No part of the wall should rest on them; nor should they be run into chimneys on account of the danger from fire. Iron could with advantage largely replace timbers in barracks; being not liable to combustion, decay, or impregnation with organic matter. It has, however, the disadvantage of rendering floors somewhat more conductive of sound.

The method of constructing floors and ceilings is of much importance in retaining heat. In cold climates, where the floor is of poor character, it is difficult to secure anything like evenness of temperature in a room. In the roughly constructed barracks of the abandoned post at Poplar River, Montana, the temperature during winter was noted as 30° F. higher at a point six feet above the floor than at the level of the latter. For ordinary purposes, wood is the best material for flooring. The material should be of good quality—hard wood, if possible—and should be tongued and grooved. If the latter material is not used, open seams invariably result

from the unavoidable shrinkage of the lumber. Fire-proof floors are made of iron beams embedded in cement, on which is laid a solid wooden floor-surface. These are now always put into German barracks. In certain French barracks, movable floors, made of boards tongued and grooved at the ends as well as the sides, have been used to facilitate cleansing of the under-spaces. Such an arrangement is both unnecessary and undesirable. With wood floors, skirtings are employed to hide the joint between the walls and floor-boards. They are preferably let into a groove in the floor, thus preventing draft and the accumulation of dust. Floors of cement or tile are too cold for northern climates, though admirable for the tropics. Cement gives rise to a highly irritating dust, while tile and mosaic soon become rough and uneven. Bitumen has been recommended for floors, as not wearing readily and being easily repaired. For lavatories and latrines the best flooring is the so-called "terrazzo," consisting of small pieces of marble laid together in cement and then smoothed down. A latticed wooden standing-board may be placed over it where required.

The height of the ceiling is a matter of great importance in barracks, since low-ceiled rooms are hot and close. For temperate climates the height of the ceiling should be about twelve feet; for warm climates fourteen or fifteen feet. If the height be too great, much difficulty in warming will be experienced during winter.

The space lying between the floor and ceiling of consecutive stories is often a source of danger in barracks of old or improper construction. It being desirable to prevent the passage of heat, odors and sound, builders not rarely partially fill the spaces between joists with so-called pugging; usually composed of plasterers' rubbish, but sometimes of sawdust, tan-bark, chopped straw or similar substances. All these are inflammable and liable to decay, and hence are objectionable. Further, these interspaces may afford lodgment to pathogenic micro-organisms; and even if the material used for filling be originally clean, it soon becomes infected. Dust, bacteria and moulds sift in through the cracks, often in large quantities. Water used in washing the floors percolates through, carrying organic matter with it; and in the warmth, darkness, and stagnant air of the underlying space the bacteria find conditions favorable to their development. Later they may be driven back into the barrack-room by air currents resulting from agitation of the flooring; and thus, even if the floor itself be clean, dangerous sources of infection to inmates may be constantly close at hand. Putzeys states that in some cases the soil in the vicinity of latrines is no more dangerously contaminated than the material found between the floors of barracks. Notter found large collections of organic débris under floors; and Uffelmann has reported an instance in which a cubic meter of material removed from such spaces, weighing 1,510 kilograms, lost by calcination 118.5 kilograms—not considering 24 kilograms of water—and contained 1,718 gm. of nitrogen and 508 gm. of nitrous acid. Laveran states that the tearing up of floors in old barracks has apparently often given rise to outbreaks of disease. To prevent these interspaces from being a source of danger they should be orginally clean and free from all foreign matter. The flooring should be double, with tight seams; the upper layer being of tongue and groove boards running at right angles with the lower layer. Between these two

layers there should be a thickness of heavy water-proof builders' paper, with the edges of the strips well overlapping. The interspace is thus completely shut off from the room above. Where flooring is laid above earth the same arrangement should be employed. The subjacent space should not be too small, and should be kept dry, carefully policed and well ventilated. New flooring should never be put down over old floors, which are worn, filthy and often infected. To do so is to preserve the dangerous qualities of the latter.

Slates furnish the best material for the roofing of barracks. They should be smooth, hard, but not brittle, and give a metallic resonance when struck. They should not take up water readily, and when stood on edge in water for half their depth, for several hours, the water should not rise to the top. In laying slates they should overlap two or three inches; the flatter the pitch the greater the overlapping required. Large slates are usually laid at a slant of 22°, while an angle of 26° is required for smaller slates. The roof should be boarded over and covered with heavy builders' paper before the slates are put in position, the paper rendering the barrack cooler in summer and warmer in winter. Corrugated iron, zinc and tin roofs are not suitable for barracks through their great conductibility for heat. According to Grunzweig, if the conductibility to heat of a roof made of wood and cement is 100, it is 265 when made of corrugated iron. When made of double planks separated by a layer of air of 30 millimeters thickness, the conductibility to heat is 99; while where tiles are used and are made to overlap three times in one foot the conductibility to heat is but 58. From this it is apparent that tile retards the passage of heat more than four times as much as does corrugated iron, and is hence far superior for use in barracks, especially in hot climates or the tropics. Where tiles are used, a slant of 45° is required to give the best results in shedding rain. Tiles should be well baked, hard, and as little absorbent of moisture as possible. If zinc or tin roofing is employed, their faults as regards the conduction of heat may be to some extent overcome by a double roof, with ventilation of the interspace. Such metal plates may be laid nearly flat, at an angle of only 4° to 5°, with their edges overlapping to allow for expansion and contraction. Shingles should not be used for the roofing of barracks where better material can be obtained. As to form, the mansard roof is of much value in protecting the remainder of the building from extremes of temperature. The space under this roof, however, is unfit for occupancy by troops. Defects in roofs are a frequent cause of dampness, and these are especially liable to occur around chimneys and partition walls. Gutters in such places should be of lead. Eaves are finished in different ways. They should always be provided with gutters to throw the rain well away from the walls, and where the latter are not given considerable slope—which is unsightly—they must be larger than would otherwise be required. Drain pipes from the gutters must be fastened well away from the wall, to prevent soakage of the latter should the pipe break or become clogged. Such pipes should never be connected with ground drains or sewers, but should discharge over a grating in the open air.

Chimneys should be higher than surrounding buildings, so that their draft may not be in any way interfered with. Each fire should have its separate flue clear to the top of the building. This should be circular,

as straight as possible, and smooth and plastered inside. Iron castings are sometimes used to line flues, these separating the flues from the house-structure and maintaining a better draft.

The number and size of windows to be placed in barracks must depend to a considerable extent upon climate. Usually there should be one window to every two beds, equalling in area one-eighth to one-sixth of the wall space. Windows are always to be placed opposite to each other, and should run from a point about $3\frac{1}{2}$ feet above the floor line nearly to the ceiling. The upper sash should be freely movable; and may, in warmer stations, be made so as to swing inward. Windows are weak points in the structure of barracks in cold climates, having a high diathermancy. For such climates, double windows and doors should always be provided, and the distance between these also notably affects the loss of heat. The German Government has adopted the following for loss of heat by windows: Heat transmission in British heat units—per square foot, per hour and per degree differences in temperature—0.776 for single windows and 0.518 for those provided with double sashes. These figures are increased by ten per cent. for very exposed situations. The actual economy in heating by furnishing storm windows to barracks is evidenced by the above. Sometimes double panes of glass are set in the window frames to retain heat, but these are quite inferior to double sets of sashes for this purpose. For summer use or hot climates, screen doors and windows are a sanitary necessity. The men must be able to eat and sleep in peace and comfort; besides which flies and mosquitoes play important parts in the dissemination of certain diseases which are especially prevalent and fatal among soldiers. At warmer stations, galleries on the southern exposure of the barracks are essential.

For the inner finishing of barrack walls nothing has been found more satisfactory than lath and plaster, furred out from the main walls at a distance of two inches. Ordinary plaster, however, has many disadvantages, being porous and readily absorbent of moisture and organic matter. Such plaster is used in most foreign barracks, but is scraped and whitewashed every six months as a sanitary precaution. This latter practice should be adopted in our service for all old barracks. While walls should be of porous material on account of their lesser conductibility as regards heat, it is none the less true that their surfaces should be non-absorbent. For the outer surface such a quality is valuable as largely preventing the penetration of atmospheric moisture or storm water. For the interior aspect impermeability is also important; since it has been shown by Vallin that the close and often offensive odors found in some barracks depend chiefly upon the impregnation of porous walls and floors by organic matter, deposited upon these cold surfaces as the result of condensation of the vapor given off from the breath and other sources. While organic contamination in this manner is at no time great, it is carried on indefinitely and the results are ultimately marked. For these reasons, efforts looking to the rendering of walls impermeable should always be made. In many of our new barracks adamant plaster is used, as being harder and less porous. The soapstone finish, a superficial layer composed of two parts plaster and one of soapstone, is hard, smooth and may be washed. Several proprietary preparations, capable of being applied by either brush or spray, are now used to harden plaster walls and render them less absorbent. Oil paints,

varnish and asphalt have been much employed for the same purpose. Laveran recommends the use of paraffin dissolved in petroleum or turpentine. Rough-finish plaster walls should never be allowed in barracks, as serving to catch and retain dust and bacteria. Wainscoting, about barracks, is to be absolutely condemned; being absorbent of odors and organic matter and soon becoming infested with insects. The corners of barrack-rooms should invariably be rounded to facilitate cleansing; not only at the junction of walls, but also where the walls meet the floor and ceiling. This rounding need not be excessive to answer all purposes.

Arsenic is not infrequently found in certain colored paints, especially various shades of green. These should not be used about barracks; since the arsenic is liberated in combination with the hydrogen of the air, and when respired may produce chronic arsenical poisoning. Zinc paints appear to be more durable than lead paints and possess no toxic qualities. Silicate paints have been recently introduced and are said to be very satisfactory. The so-called "duresco" hardens the surface to which it is applied, can be washed, is not toxic and repels moisture.

Barrack Furniture and the Care of Barracks.—The furniture of squad-rooms includes shelves and hooks for clothing, lockers, beds, bedding, chairs and gun-racks.

Shelves, usually double, are provided in nearly all barracks. They afford a convenient and, in fact, the only practicable place for keeping the more bulky articles of the uniform, and are much appreciated by the men. Usually of such a height as to permit the clothing-hooks to be hung below, their upper surfaces are thus not readily open to inspection. From this fact, accumulations of dust are liable to occur upon them, these to be later disseminated by brushing or by currents of air. To prevent this they should be wiped off weekly with a damp cloth, all articles being removed from them for the purpose. That such cleansing has been properly carried out is readily determined by touch with the white glove. In many barracks, company commanders have authorized the use of pieces of colored cloth, tacked on the upper shelf to hide the lower shelf and the garments hung below it. This custom should be opposed as favoring stagnation of air, a lack of order and the possible retention by the men of articles undesirable in a squad-room; and in addition such curtains themselves soon become soiled, dusty and unsanitary. The latter faults might be partially remedied by frequent washing, but this will in practice rarely be carried out.

Lockers afford security and a convenient means of caring for the smaller articles of clothing and personal property. They are chiefly supplied in the form of low wooden boxes, with a single tray, capable of being pushed under the bed. In the barracks of later construction, however, lockers are built against the wall in the form of small closets. These usually soon become infested with vermin; and being fixed, they cannot be removed for sunning and cleansing as can the box lockers. From a sanitary standpoint they are much less desirable than the latter. Lockers require careful inspection, since soiled and damp clothing is often kept in them to the detriment of clean apparel.

Barrack bags, of brown cotton duck, are now supplied as receptacles for soiled clothing prior to washing. They are excellent for this purpose, but

must themselves be frequently washed, since otherwise in hot weather they become odorous and are apt to afford lurking-places for insect parasites. This washing is, unfortunately, rarely performed.

Much improvement in the sleeping arrangements of soldiers has been made of late years in all armies. This is particularly noticeable in our own service, which is far better equipped, in this respect, than are those of foreign nations. Not fifty years ago, in the British army, even at tropical stations, wooden bunks were usually built in several tiers against the walls of the barrack building. At other barracks in England there were large beds, in which four men were compelled to sleep together; a requirement naturally conducing to dirt, disorder and immoral practices. At the present day, in the French army, the beds are double, and two men must sleep together. This practice is unsanitary and is repulsive to the better class of men. In our own service two-tier double bunks were used until a comparatively recent period, their abolition being a great sanitary advantage. The British soldier at Hong-Kong provides his own bedstead, a custom long prevalent in the British service in India. It is remarked that as a result of this custom uniformity in appearance is lost, an undue amount of barrack space is occupied and the existence of insect parasites is favored.



FIG. 200.—Barrack Bag.

At present, cot-beds of two patterns are supplied in our service. One consists of iron trestles supporting an elastic framework of slats. This pattern is not comfortable, and should be entirely done away with as being difficult to clean, absorbent of odors and retentive of vermin. A double bed very similar to this bunk is used in the French army. Comparatively recently a single bed, made of iron throughout, with woven wire springs

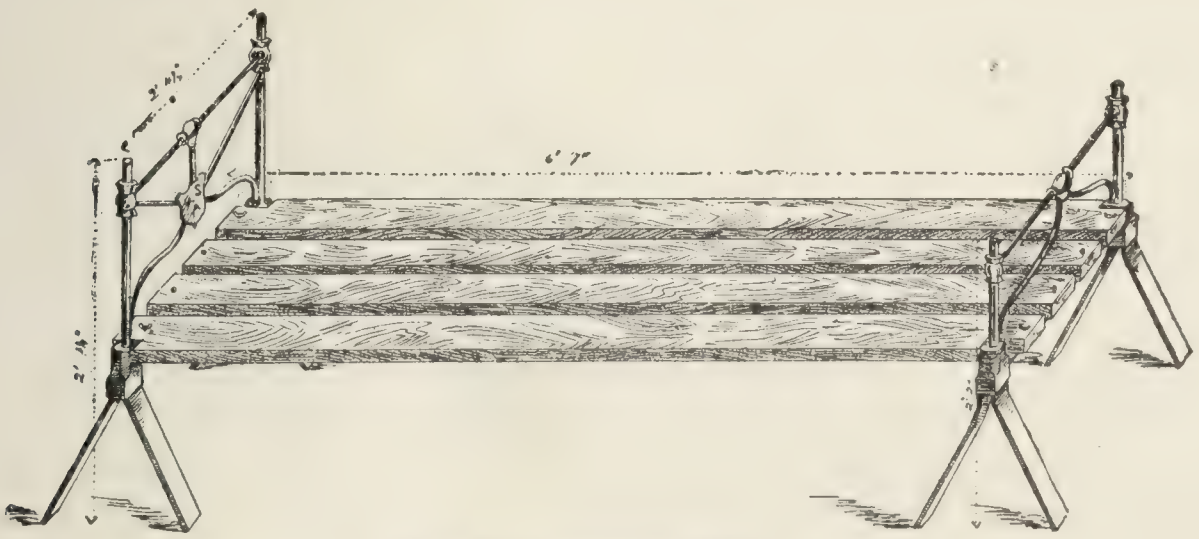


FIG. 201.—Composite Bunk.

and mosquito frames, has been supplied. This is well adapted to military uses and is far superior to similar articles supplied in other armies. It is comfortable, solid, substantial, sightly and readily cleaned. The present method of fastening the woven wire, with a wooden cleat at the end of the frame, is undesirable, however, since it affords a refuge to bed-bugs from which they are dislodged with difficulty. The bed also might with

advantage be made two inches longer, and in damp localities the woven wire fabric sometimes rusts. This latter fault can be prevented by care and an occasional wiping with a rag slightly moistened in mineral oil. Beds should be thoroughly overhauled and cleaned whenever vermin appear to be present. The wire netting should habitually be well brushed, in the open air, once a fortnight. In barracks the heads of beds should be kept at a distance of six inches from the wall.

A large number of folding canvas cots, as described in a previous chapter in connection with their field use, have been lately supplied to troops in the tropics. They are comfortable and convenient, but, although excellent in camp, they can by no means replace the bed just mentioned for barrack use.

Hammocks have been recommended for military purposes. These are much less comfortable than beds, and economy of space is by no means as

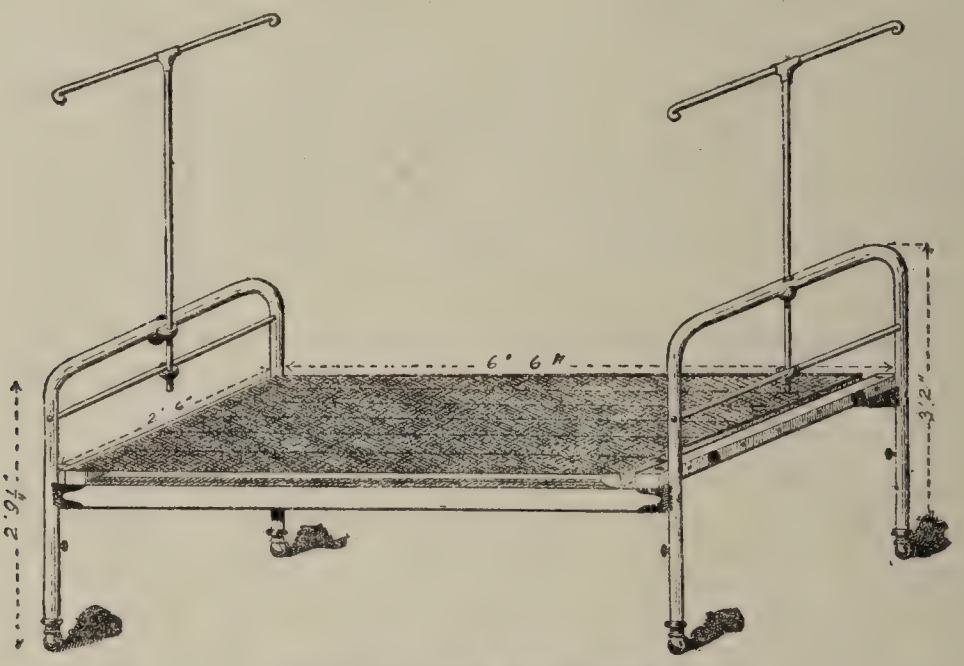


FIG. 202.—New Model Bunk.

essential in permanent habitations on shore as on ship-board. In any squad-room where such economy of space appears desirable it is evident that over-crowding exists.

In this connection, mention may be made of bed-bugs, which, once introduced into a squad-room, multiply rapidly in the cracks and crevices of the walls and floor, the beds and bedding. A large number of eggs are laid at a time, hatching being accomplished in ten days and maturity being reached in about seven weeks. These insects are very long-lived, and have been shown to be capable of existing without food for over a year; hence old barracks, long unoccupied, should be carefully gone over before being used by troops. Swallows' nests and old cottonwood logs appear to harbor an allied species, if not the same insect.

Bed-bugs are of no small sanitary importance from the fact that by their persistent attacks soldiers are deprived of much needed repose; and when these insects are crushed on walls or bedding they leave unseemly smears and give rise to unpleasant odors. Further, there is some evidence as to their being capable of transmitting disease from the sick to the well by their bites. When once introduced into a squad-room, bed-bugs can be kept under only by constant effort, especially in warm weather. To furnish few hiding-places for these pests, beds should be made of iron, and so

constructed as to be readily taken down for cleansing. Floors should be rendered impermeable, and the cracks filled up, by one of the methods subsequently described. Walls should be plastered; avoiding wainscoting as above all certain to afford a ready harboring-place, from which the dislodgment of these insects is difficult or impossible. In log barracks or those constructed of adobe, their extermination becomes a matter of the greatest difficulty; their almost inevitable presence causing much discomfort among the inmates. For the destruction of bed-bugs frequent shaking, beating and sunning in the open air of all bedding, pillows and mattresses is required. Where their presence is noted in beds, the latter should at once be taken apart in the open air and scrubbed with hot water and soapsuds. The beds may then be gone over with an emulsion composed of one part of petroleum to four parts of water, applying it well with a stout brush. Both the bugs and their eggs are readily destroyed by this treatment. Scalding water may also be used for the same purpose. A saturated solution of bichloride of mercury is very efficacious if brought in contact with the insects or their eggs. Benzine and gasoline appear to destroy these vermin, in any stage of development, almost instantly. For cracks in walls the latter substances are best applied in the form of a spray, an apparatus for the production of which can be readily improvised by the aid of a bicycle pump or large syringe. When these substances are used in a squad-room, however, the latter should be closed to those not engaged in the work until the inflammable fumes are dissipated, which soon occurs. For articles which cannot be moved, pyrethrum or Persian powder has been much used; being insufflated into all possible lurking-places for these pests. This powder has no effect upon the eggs of the insect, and hence the relief afforded is only temporary in its nature. In addition, its use is not particularly cleanly. In the absence of a more destructive agent, bed-bugs can be driven away from a bed by washing it with a mixture made by crushing the berries of the cedar tree in hot water. For satisfactory results, it is necessary that this liquid be applied weekly.

Where a barrack has become generally infested, the insects are best destroyed by fumigation with sulphur dioxide. The entire building, however, must be fumigated at the same time to prevent incomplete results from the passing of the bugs from one room into another during the operation. Formaldehyde gas is not efficacious in the destruction of these pests. In general, the use of gaseous insecticides implies the complete evacuation of the building for twenty-four to thirty-six hours, and hence will not always be conveniently applicable. It can, however, be readily carried out during practice marches or by placing the command under canvas at any time, and the thorough destruction of vermin thus ensured is ample recompense for any discomfort incurred in the attainment of this object.

With respect to bedding, our soldiers are now supplied with mattresses, which would be all that could be desired for comfort were they a little thicker. It would be an advantage from the standpoint of economy and cleanliness if they were made in three equal parts, any worn or soiled portion being thus readily removed for condemnation. Mattresses should be thoroughly brushed in the open air and exposed to the sun at least once weekly. In the prevention of vermin, especial attention should be given to cleanliness of the folds and about the tufts. Mattresses should never

be used without the cover provided. The latter should be washed at least every two weeks, and oftener in warm weather.

Bed-sacks are nominally issued in our service, but in practice they are rarely used except for prisoners. For troops in semi-permanent camps their great transportability may at times commend them; and the same applies to their use in field hospitals. When mattresses are not supplied and bed-sacks are issued, regulations authorize the monthly issue of thirty pounds of straw, per man, for use as bedding. In the German, French and British services the soldier still sleeps on straw, the allowance per man, in the last army, being twenty-four pounds per quarter. In the French army but twenty-two pounds of straw are allowed every six months. Both of these allowances would seem to be quite insufficient for proper cleanliness, since unless the straw is frequently changed it soon harbors insects. Bed-sacks, where used, should be washed at least monthly. The straw should be removed with care to avoid raising a dust, and should be at once burned. Frequent sunning and shaking is of great importance.

The pillows supplied in our service should be made slightly larger, since when matted down by use they are too small and many soldiers

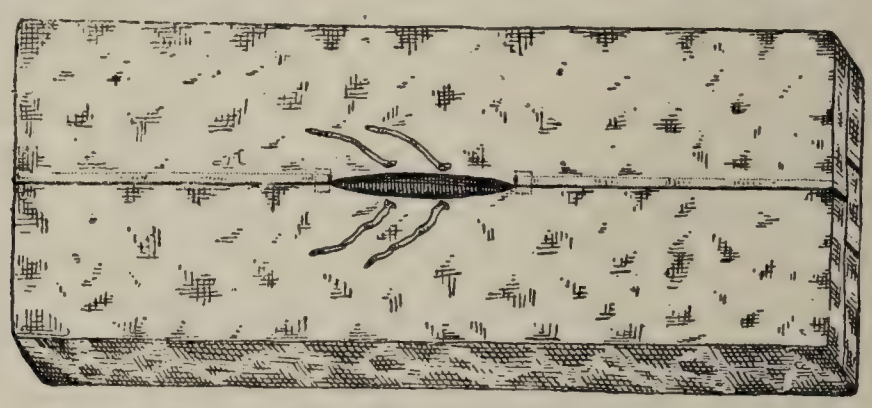


FIG. 203.—Bed sack.

habitually use rolls of clothing under them. This practice is undesirable. Clothing more or less soiled by hard usage should not be brought into contact with a clean bed, nor is the appearance of these garments improved by the process. Pillow-sacks are supplied for use where bed-sacks are employed.

The sheets provided for our troops are excellent. Those issued in the British army are said to be very coarse and unsatisfactory. Sheets should be washed at least once weekly, and this is usually accomplished in our service. In the British army the sheets are required to be washed once a month; in the French army they are washed monthly during the colder half of the year and every twenty days during the warmer months. In making the bed the sheets should be taken off and shaken, and when replaced they should be transposed. Bed-linen cannot be kept properly clean in the absence of personal cleanliness or where the men sleep in the underclothes and socks worn during the day. The latter common practice should be discouraged and the men urged to provide themselves with pajamas; or at least their underclothing should be changed and the garments worn during the day spread out to air.

Blankets are noticed elsewhere. They should be shaken in the open air and sunned as often as possible, at least once weekly. They should be washed when soiled, or under any circumstances as often as once a year;

care being taken to prevent their becoming hard and shrunken as a result of the operation.

Mosquito bars are now issued to troops in barracks, and these conduce greatly to rest and comfort. In addition, they probably do much to diminish the frequency of malarial infection. Since, during sleep, the hand or foot may come in contact with the netting and thus be stung by mosquitoes, the nets issued to malarious posts should have, as an additional protection, a gathered valance sewed around the netting, about ten inches wide and extending six to eight inches above the bed level. No smaller mesh than in the nets at present supplied is required, except where buffalo-gnats and midges abound. Mosquitoes, however, will find any rent or opening, and hence as much of the net as possible should be tucked under the mattress when the bed is made, leaving only sufficient slack to permit of entrance.

Chairs and tables possess no special sanitary importance. Where sufficient chairs are not supplied, the men are perforce obliged to sit on their beds, a practice not conducive to the appearance of neatness in the squad-room. From the fact that a majority of the inmates of a squad-room will usually be absent, the present allowance of one chair to two men will ordinarily be quite sufficient. In the German army a stool is supplied to each soldier. Tables are not a necessity in squad-rooms.

Gun-racks and their contained fire-arms were long kept in squad-rooms. In more recent barracks, however, a small separate room has been provided for their reception, where they are kept in charge of a non-commissioned officer. This change is very much of an advantage, since additional space is thereby saved in the squad-rooms, and the atmosphere in the latter is rendered free from the odor of burned powder and oil. The greater difficulty in securing fire-arms will undoubtedly have an effect in reducing the frequency of homicide and self-destruction.

Cuspidors are not supplied for the use of troops, but the necessity for their employment is recognized and every barrack contains them. Usually they are found in the form of wooden boxes filled with sawdust or sand; though sometimes tin containers, cut from the lower portion of empty oil cans, are employed. Wooden containers are soon saturated with expectorated material, become offensive to sight and smell and cannot be properly cleaned. Both sand and sawdust, contaminated with sputum, may be dried and disseminated by accident or air currents. Where these are used, the determination of the frequency of cleansing is somewhat difficult for the inspector; and sawdust, from the danger of ignition from cigar and cigarette stubs, is a constant menace to safety. For these reasons it would be advisable to issue large, galvanized-iron cuspidors, so shaped that they will not readily upset yet may be easily cleaned. These should be kept partially filled with some disinfectant solution, and be cleansed and scalded once daily. Small pieces of linoleum or rubber mat should be placed under cuspidors to prevent inadvertent soiling of floors, and these should be washed and wiped off with a disinfectant solution daily. Spitting on the walls or floors in barracks should be prohibited, and any infraction of this rule severely punished. Indiscriminate expectoration is not only incompatible with the cleanliness of barracks, but ejected material not rarely contains the micro-organisms of tuberculosis, pneumonia, diphtheria,

or pyogenic bacteria; and when such material is dried, ground to dust under the feet of passers and then raised by sweeping, air currents or other means, it may readily be inhaled and serve to determine the occurrence of these diseases in others. In our army the question of properly disposing of the sputum has not received the attention which its importance deserves. It is true that the presence of cuspidors is undesirable in squad-rooms and that the frequency of expectoration is largely determined by habit; but since no small proportion of soldiers are addicted to the use of tobacco, the necessity for providing for ejected saliva and sputum should not be officially disregarded.

Water buckets, filled with water for use in case of fire, are to be found in all barracks. These buckets should be emptied and refilled with fresh water at least three times weekly during warm weather. The water is soon contaminated with dust; and the accompanying bacteria, perhaps of pathogenic character, undergo rapid development. During the mosquito season the eggs of these insects are preferably deposited in such receptacles, and their development may be subsequently a source of much discomfort. In winter, care must be taken to prevent the contents of these buckets from being frozen. Expectoration or the throwing of articles into them should be severely punished.

Floors are an important agent in the causation of infections, and thus merit the careful attention of the military sanitarian. In barracks the floor is constantly being soiled; with saliva containing pathogenic micro-organisms; with bits of food; with mud and dirt which men carry in on their clothing and equipment and particularly on their shoes. It is therefore not surprising that many investigators have found the dust and scrapings from barrack floors to contain the germs of disease. Tryde and Salomonsen found typhoid bacilli on the floors of a barrack in Copenhagen; Uptadel at Augsburg; Birch-Hirschfeld at Leipzig; Chour at Jitomir. Emmerich found the pneumococcus on floors in wards occupied by pneumonia patients. Maximowitsch, experimenting with the dust of a hospital, states that of twenty-one guinea-pigs inoculated, nine became tuberculous; three times he found staphylococci, twice streptococci and once the pneumococcus. Cornet had similar results.

The infectious material is found chiefly in the cracks and crevices of the floor, but also on projecting ledges, shelves, and in corners. It is a comparatively small source of danger while quiescent, but when raised by currents of air, the feet of passers or by sweeping, it is widely disseminated and its opportunities for producing an infection are greatly increased. Sweeping and dusting are the great agents in its spread, and such means of cleansing should be prohibited. The necessary cleansing is not only more safely but also more effectually done by the use of damp cloths and mops; the moistened dust being rendered incapable of rising, and hence being actually removed instead of being largely raised from one portion of a squad-room to be deposited over the floors and furniture at the other end of the apartment, later to be taken into the system as a result of contact or inhalation. In some instances, floors are cleaned by the wet method; but this procedure, unless properly carried out, is not without serious faults. Ordinarily by far too much water is employed for this purpose. Unless directed to the contrary, soldiers will almost invariably dash it on

in bucketfuls—the floors subsequently requiring hours to dry even under favorable circumstances. In many instances, inspectors have found that holes had been bored through the floors and the dirty water flushed over them allowed to escape to the soil beneath, thus providing every facility for the development of bacterial life. In other instances, foul water, charged with organic matter and microbes, escapes through cracks into the space between floors, keeping up a constant moisture, favoring the development of germs and inducing moulding and decay of the boards and joists. Damp floors have long been recognized by sanitarians as potent factors in the production of disease, more directly in the production of tonsillitis and pharyngitis. By line officers, however, the necessity for the use of but a small amount of water on floors is not generally appreciated, and a general order on this subject might well be promulgated. Floors should be cleaned with mops only slightly moistened, and these be frequently wrung out in buckets of hot soap-suds. The method is slightly more laborious, but it is also much more conducive to health. In the British army the wet scrubbing of floors is prohibited at periods oftener than once weekly. During rainy or damp weather the use of any but a very small amount of water on floors should not be allowed.

In order to use water more safely on floors, and at the same time to prevent absorption of organic matter and micro-organisms by the latter, all floors in barracks should be rendered impermeable. In this respect the United States army is behind those of many other countries, in which the desirability of rendering barrack floors non-absorbent is officially recognized. In our hospitals the necessity for this quality in floors has long been appreciated and satisfied, and the arguments in favor of it for such buildings apply equally to barracks. Aside from its sanitary value, the proper rendering of floors impermeable at once imparts an air of neatness to a squad-room which can be obtained in no other way, and at the same time diminishes future labors with respect to cleansing.

Many methods have been proposed to render floors impermeable. Mangenot advises that barrack floors be given a coating of bitumen. This has been tried in the French army and found to be somewhat cold during the winter, and in the hot season liable to soften under pressure, particularly under the legs of beds. It presents, of course, an entirely impervious surface which can be readily washed and disinfected, and abolishes all danger of infection from the planking or spaces underneath. Waxed floors, as sometimes suggested, are too costly for military use and take up much dust. The wax also has to be renewed at frequent periods. Among other methods, the use of linseed oil, tar and paraffine has been advised. In the German army, linseed oil is employed for this purpose. It is applied boiling-hot with a stiff brush, and, as far as impermeability goes, the result is satisfactory after several applications have been made. Subsequently the oil must be applied twice yearly. This method appears to have many disadvantages. The oil does not fill the cracks, dirt adheres to floors so treated and gives them a bad appearance, and cleansing is said to be difficult. Further, floors soaked with linseed oil acquire a very disagreeable and persistent odor. In the French and Austrian armies it is ordered that the barrack floors shall be rendered impermeable by the use of coal-tar—a board of officers in the first named service having reported upon this sub-

stance as giving the most satisfactory results for this purpose. A recent order in the French service directs that, for application, the tar should be mixed with boiling water in the proportion of 3 kilograms of tar to 1 liter of water. In this proportion it is said that the tar and boiling water mix readily, good results are obtained and drying is rapid. The mixture must be constantly stirred during the application, which is best performed with a stiff brush. The tar may also be applied pure, or mixed with turpentine. By its repeated application the cracks are gradually filled up. The color imparted is brownish and unsightly, but otherwise the method gives very satisfactory results. The best procedure is undoubtedly that depending on the use of paraffine, as carried out in our own military hospitals. In this method the floor is cleaned and dried. It is then lightly covered with grated paraffine, and this is melted into the floor with a large hollow iron containing burning charcoal. Under such heat the paraffine penetrates the wood to about one-fourth of an inch. The excess of paraffine is then scraped off and the floor given one or more coats of a solution made by dissolving one ounce each of wax and paraffine in one quart of turpentine. Subsequent applications of this solution should be made once a month. Wood so treated becomes not only impermeable to moisture, but its cracks are filled up, it is hardened and less liable to splinter, takes on an agreeable appearance and is susceptible of high polish. While the best results are obtained with well-built floors made of good material, it is safe to say that there are no floors in our barracks which would not be improved, from a sanitary, æsthetic and economical standpoint, by the proper application of paraffine.

Fleas not infrequently develop in large numbers on barrack floors during warm weather, and the discomfort which they cause is often considerable. They have also been shown to play a part in the dissemination of bubonic plague. These insects are introduced into barracks by dogs, cats and pet animals; their eggs being deposited between the hairs of the host, but not attached to them, so that they are scattered by movements. They are especially common in the places most frequented by infested animals. The life cycle of the flea, according to Howard, is complete in seventeen days; the young developing in the dust in cracks or crevices of the floors. The eggs are not likely to hatch when disturbed. Prevention of annoyance from these insects depends upon exclusion of pet animals from squad-rooms during warm weather, the impermeabilization and frequent cleansing of floors, the use of pyrethrum powder and the mopping down of floors with strong bichloride of mercury solutions.

Casemates.—Many casemates are still employed as quarters for troops, in spite of the adverse report of probably every medical officer who has had to do with them. They are dark, damp, ill-ventilated and mouldy, and such qualities cannot fail to have their effect upon sick rates. In the citadel at Ghent, in 1845–46, it is stated by Ordroneux that those troops which were lodged in subterranean apartments had twice as many sick as those quartered above the surface of the ground. At Fort Clarence, in England, it was shown that men quartered in casemates were twice as liable to tuberculosis as those in the ordinary buildings. In 1898, in our own service, it was found that at Fort Adams, for the previous ten years, the average annual rates for rheumatism were 84 for the part of the garrison

living in casemates and 56 for the soldiers living in a light and airy barrack building. For the previous three and one-half years the casemates gave 61, the barracks 30. Diarrhœa also affected the men in casemates more than those in barracks, in the proportion of 104 to 74. Many casemates no longer occupied by troops are used as quarters for married soldiers; and their children, living under such conditions, are notably wan, sickly, rachitic and tuberculous.

In the original construction of casemates in our service, brick arches were covered with sheet lead and the intervening valleys filled with earth. A thin layer of concrete with brick pavement completed the roofing. The weight of this roofing, in course of time, has in nearly all instances forced the underlying hard parts through the sheet lead, thus giving rise to leaks which are frequently of large size. At Fort Trumbull, in 1895, examina-

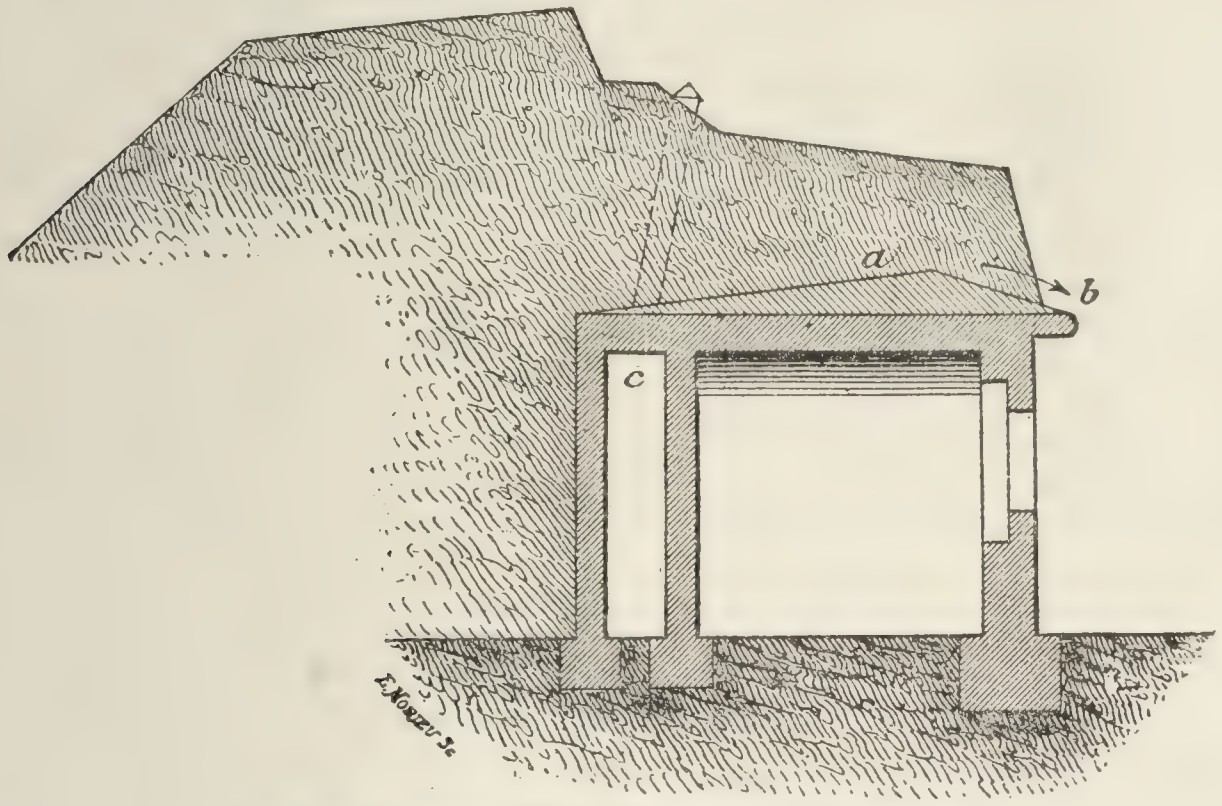


FIG. 204.—Improved Plan of Construction for Casemates.

tion of casemates unoccupied for some time disclosed water standing under the floors at a level of ten inches. The natural dampness of such casemates predisposes to rust, mould and decay, and fires must be maintained by their occupants, even in the hottest weather, to dry the air. Chilled in winter, casemates retain a low temperature well into summer. This has been explained by the finding of ice in the depressions between arches, when uncovered for repairs, well into warm weather. Such conditions result in added dampness of casemates, through the condensation on the walls of moisture from the entering warm air.

Casemates will probably rarely be necessary in future fortifications, except in such number as would afford sufficient protection during action. Where they are required, a space should be constructed between the inner wall of the casemate and the rampart, as shown in the accompanying illustration, and this should be properly supplied with flues to secure ventilation and dryness. The roof of such casemates should be covered with a heavy coat of cement, and possess a considerable slant to better turn aside the water which percolates through the earth. The future use of sheet lead, as a roofing material, should obviously be avoided.

Casemates are totally unsuited for the shelter of troops and should never be employed for this purpose, unless temporarily in time of war. Modern barracks and quarters should be constructed outside the permanent fortifications, but in their vicinity, and should preferably be made of wood to facilitate their future destruction if this at any time be required for military reasons. The quartering of troops in casemates during time of peace cannot be justified in any manner.

Guard Houses.—Of all the buildings at our military posts, the guard houses are those which call forth the greatest number of complaints as to the insufficiency of their accommodation, want of proper ventilation and generally unsanitary condition. So frequent have these criticisms been, of recent years, that it would almost seem as if the authorities had tacitly regarded unhygienic surroundings as part of the penalty to be incurred for military offenses—apparently not taking into consideration the fact that, where guard houses are bad, guard duty itself, for those detailed for its performance, practically becomes an undeserved punishment. As far as the prisoners are concerned, also, even though confinement results from the voluntary commission of offenses entailing a known penalty, the Government possesses no moral right to jeopardize health through the withholding of proper sanitary surroundings. The plainest fare, the hardest bed and most rigid confinement should in no way interfere with the strict observance of hygienic detail in the arrangement and management of the prison and care of the prisoners. Recently this fact appears to have been more fully appreciated, and an earnest effort is being made to better the prison facilities throughout our service. Many guard houses have lately been remodeled and new ones built.

In the construction of guard houses, the same general principles apply which govern the construction of barracks. In some respects these are even more important—from the restricted life led by the prisoners; the arduous and often uncleanly nature of their duties; their frequent lack of soldierly interest with respect to the care of their persons and surroundings; and finally, the fact that all the inmates are constantly present at night, and no deductions can be made—as is the case with barracks—for absence on military duties. An abundance of floor and air space must be provided. Small cell-rooms should never be constructed, but all cells should be in the form of iron cages, in large well-lighted and well-aired rooms, with a free passage-way on all sides. Where the old system of small individual cells with solid walls is in use, it should not be forgotten that greater floor and air space must be provided for each man than would be required for general squad-rooms. Usually the ventilation in cells of this character is very defective, and measures should be taken to remodel guard houses having this system of confinement in operation—particularly since the use of night-buckets is generally required of prisoners. Where it is contemplated that prisoners should eat their meals in the guard house, a separate mess-room should be provided. There should be ample latrine and lavatory facilities, and these should be located in an addition having three sides exposed to sun and air. The great frequency with which guard houses become infested with vermin render the employment of impermeable walls and floors a sanitary necessity.

Quarters.—The quarters of officers will usually be found of good char-

acter and well cared for. They are ordinarily much better constructed than barracks, and are generally comfortable. To this, however, there are some exceptions. Officers' quarters, under present conditions, can rarely be overcrowded, and hence neither size nor ventilating facilities require serious attention. The most grave defect in quarters of this character is the general absence of bath-rooms and water-closets—a fault which has fortunately been remedied in most of the buildings lately erected for this purpose. The controlling authorities have long insisted upon the erection of officers' quarters in double sets under one roof. This saves the cost of one gable wall and makes the houses somewhat warmer, but to offset this, one half of these quarters never receives its full share of sunlight and is often cut off from prevailing winds. Single sets of quarters, with free exposure on all sides, are much to be desired; and in the military service the slight increase of land required for such improvement cannot be a consideration.

The quarters occupied by married soldiers and their families, at the larger proportion of our posts, are usually poorly constructed, worse kept in repair and much over-crowded. Usually of too limited number and capacity to accommodate the considerable number of families requiring shelter, at a number of stations the complaisance of commanding officers has resulted in the erection of flimsy and unsanitary structures, often in considerable numbers, built by the men from such waste lumber, refuse canvas and old tin as could be obtained. Such quarters are offenses against not only the sanitary condition but the appearance of a post. To permit their occupancy is to do injury to the health of their inmates and to maintain foci from which disease, favored by their unsanitary character, may readily spread to troops in barracks. As long as buildings of this kind exist, they will usually be occupied and afford an excuse for the presence at the post of unauthorized camp followers, often of an undesirable character. Such buildings should be destroyed at all stations throughout our army, and the erection of any structures of similar nature forbidden in the future. At all posts there should be sufficient quarters of good character, provided by the Government, to furnish accommodations to a fixed percentage of married soldiers, based upon the maximum strength of the garrison. This percentage should apply throughout the army, so that on the changing of station by troops the number of families of soldiers who possess a legal status may be sure of proper habitations wherever they may be. In France, quarters are provided for four married soldiers in each regiment. This allowance is obviously quite insufficient for our service.

From the constant communication between the barracks and the quarters of married soldiers, it is evident that unsanitary conditions in the latter will not be without unfavorable influence on the health of the troops generally. There should, therefore, be careful hygienic supervision over them. It would be of great advantage if each company commander were required weekly to inspect the quarters and premises occupied by the civilians attached to his command—the same as he inspects his company barrack—and be held accountable for the proper condition of the same.

Hospitals.—All that has been said with respect to site, surroundings, general method of construction and care of barracks applies with even greater force to hospitals. In posts, the hospital should be located well

away from other buildings, but at the same time should be within reasonable distance of the troops whose needs it is to serve. General hospitals should be at central points possessing numerous lines of communication. They should not adjoin posts or garrisons, to prevent possible attempts at interference with their administration on the part of commanding officers of the latter. Military hospitals are conveniently grouped into those of a permanent and those of a more or less temporary character; the latter in our service being divided into frame pavilion and tent hospitals. In many foreign armies, especially where the number of troops stationed in a town is not large, certain portions or wards of civil hospitals are devoted to military use; the soldiers admitted to them being exclusively under the treatment of military medical officers. This practice has not been employed in the United States service. In time of war, when the capacity of military hospitals is temporarily exceeded, sick soldiers are often transferred to civil hospitals for treatment; but under such circumstances they are placed entirely under the control of the medical staff of these institutions.

In every hospital, of whatever size, there must be a portion devoted to administration purposes, general and isolation wards and their accessory rooms, operation-room, dispensary, laboratory, mortuary, mess-hall and kitchen. In large hospitals there should also be a laundry. The precise disposition of these essential parts of a hospital depends upon the size of the institution and the funds available for its establishment. Where possible, separation of the wards and administration building should be aimed at; also separation of the wards from each other and from all accessory departments. However desirable it may be, complete separation of the operating-room in small post hospitals is not practicable under present conditions. In the military service, as opposed to civil life, the shape and area of the hospital site will rarely require consideration in the arrangement of the institution.

In foreign armies, hospitals have until quite recently been large, solid buildings of many stories; all the portions, accessory as well as essential, being within the same walls and in close relation to each other. In our own service, the small number of troops located at any one point has made our hospital buildings of correspondingly small size. Considerations of economy, moreover, have forced the building of hospitals of the above undesirable type and have also led to various defects in construction—no single building at a military post, without special legislative authority, being allowed to cost more than twenty thousand dollars. This requirement obviously imposes serious restrictions upon internal arrangement and construction, and prevents the adoption of a number of needed reforms. In the ordinary plan of post hospital, of comparatively recent adoption, the cost of construction is usually at the rate of about six hundred dollars per bed; but in the new hospital at Fort Leavenworth the expense per bed is double that amount. In the old frame wooden hospitals, as existing at most of the western stations, the cost of construction is about three hundred dollars per patient.

From the financial necessity of building post hospitals of a compact nature they naturally and unavoidably present very many defects, of which the accompanying plans of the new hospital at Fort Snelling furnish excel-

lent illustrations. Among these faults may be mentioned the crowding together and close connection of the administrative portion, wards, kitchen

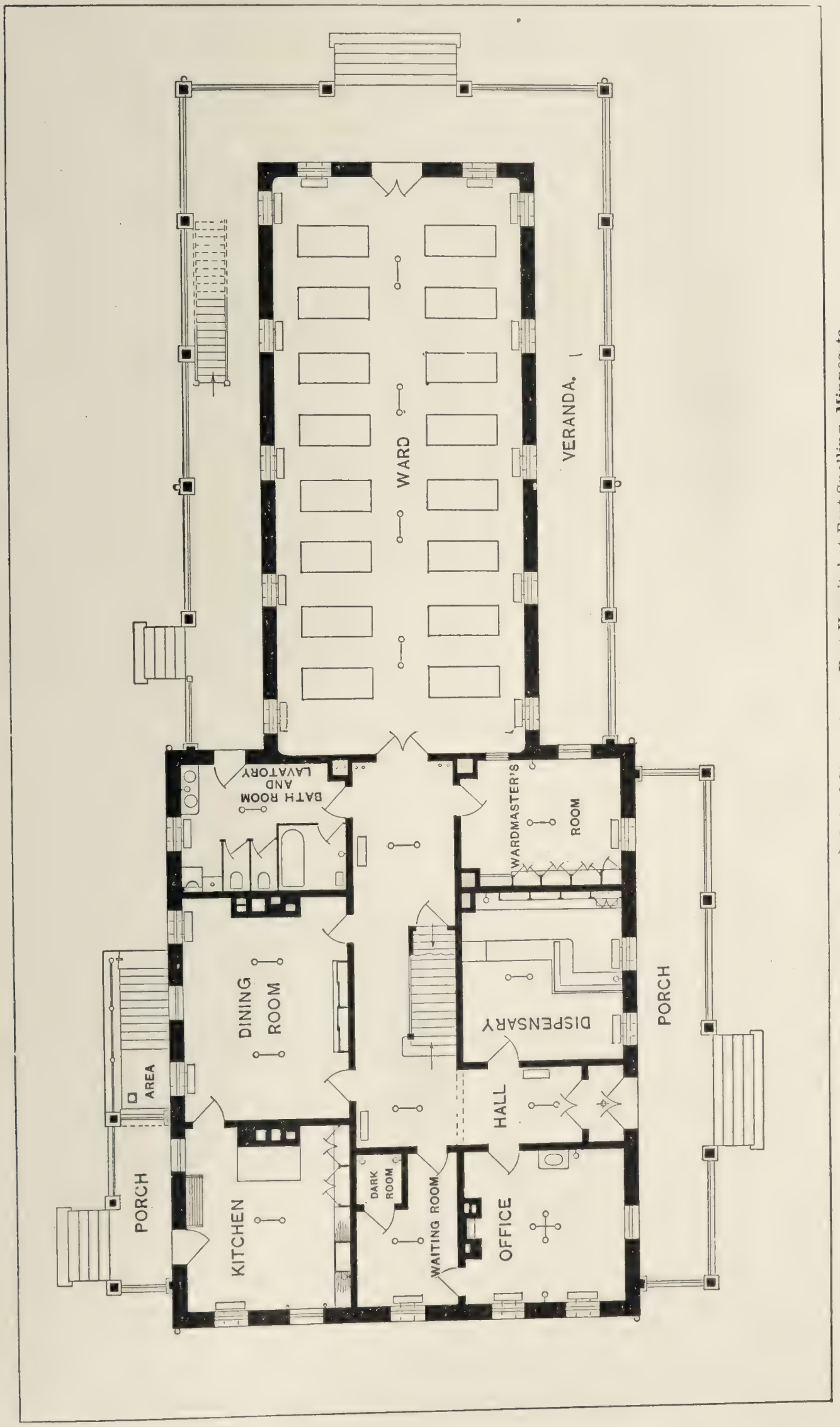


FIG. 205.—First Floor Plan of United States Army Post Hospital at Fort Snelling, Minnesota.

and lavatories, which should all be separated from one another. The lavatories especially should be outside of the main building; yet not only are they placed in this building but are located adjoining the mess-room, a single wall merely intervening between these rooms and the water-closets. The room intended for purposes of isolation is in no sense isolated, and can be reached only through the main portion of the hospital. It should be entirely walled off from the main portion, if it must be retained in the hospital building proper, and should be reached from the outside by a separate stairway. It should have a room for attendants adjoining it, and should also be provided with entirely separate water-closets and lavatory facilities. It should be ventilated separately. The office facilities in post hospitals of this character are also insufficient. In those built on the new plans, the upper floor, under the mansard roof, is usually left unfinished. In some instances the needs of the service have required the use of this floor; but the ceiling is much too low for its satisfactory use for the shelter of the sick, so that the rooms gained by finishing off this floor are extremely hot in summer and not well ventilated. They should not be employed for other than storage or for dormitories for men of the hospital corps. Whenever the probable need of using this upper floor in the future is at all apparent, the wall should be built two feet higher than in present plans, and the whole hospital building should have a double roof. This need not greatly add to the cost and would conduce greatly to comfort. The kitchens in the new post hospitals are also too small to meet the needs of any great number of sick, while their location does much to raise the temperature of the main building unduly during hot weather. The storage facilities provided are insufficient, and the present arrangement of a mortuary in the basement is highly undesirable. In spite of these defects, which appear to be largely unavoidable from financial reasons, our later pattern post hospitals compare favorably in character, so far as they go, with similar institutions abroad.

In hospital construction, the determination of the material best adapted for wall surfaces is one of the most difficult problems. An impervious surface is essential. Soap-stone finish has been much used to meet this need and is fairly satisfactory. Square corners should not be allowed, nor should any mouldings or recesses be permitted. The amount of wood-work around windows should be reduced to the minimum. In many civil hospitals the window sashes are made of iron. The floors should be well laid, solid, and free from cracks, and should be rendered impermeable with paraffine. In operating-rooms, lavatories and water-closets the flooring should be of terrazzo. Only two rows of beds should be permitted in a ward, and in many hospitals a window is located between each bed. No bed should be nearer to its neighbor than five feet; thus giving eight feet of wall space per capita. Notter and Firth recommend the provision of one square foot of window space to each 80 cubic feet of space in the ward.

As regards the internal equipment of wards in post hospitals, it should be accepted that nothing should be allowed for this purpose which is absorbent or cannot be readily disinfected. Bedsteads should be of iron throughout, and be coated with white enamel paint. Bedside and dressing tables should be of enamelled iron with smooth tops of heavy glass. The

wooden tables still in use in some of our hospitals should be abolished, and the same also applies to wooden chairs. Where such are still kept in use they should be well varnished at least twice a year. Excellent chairs

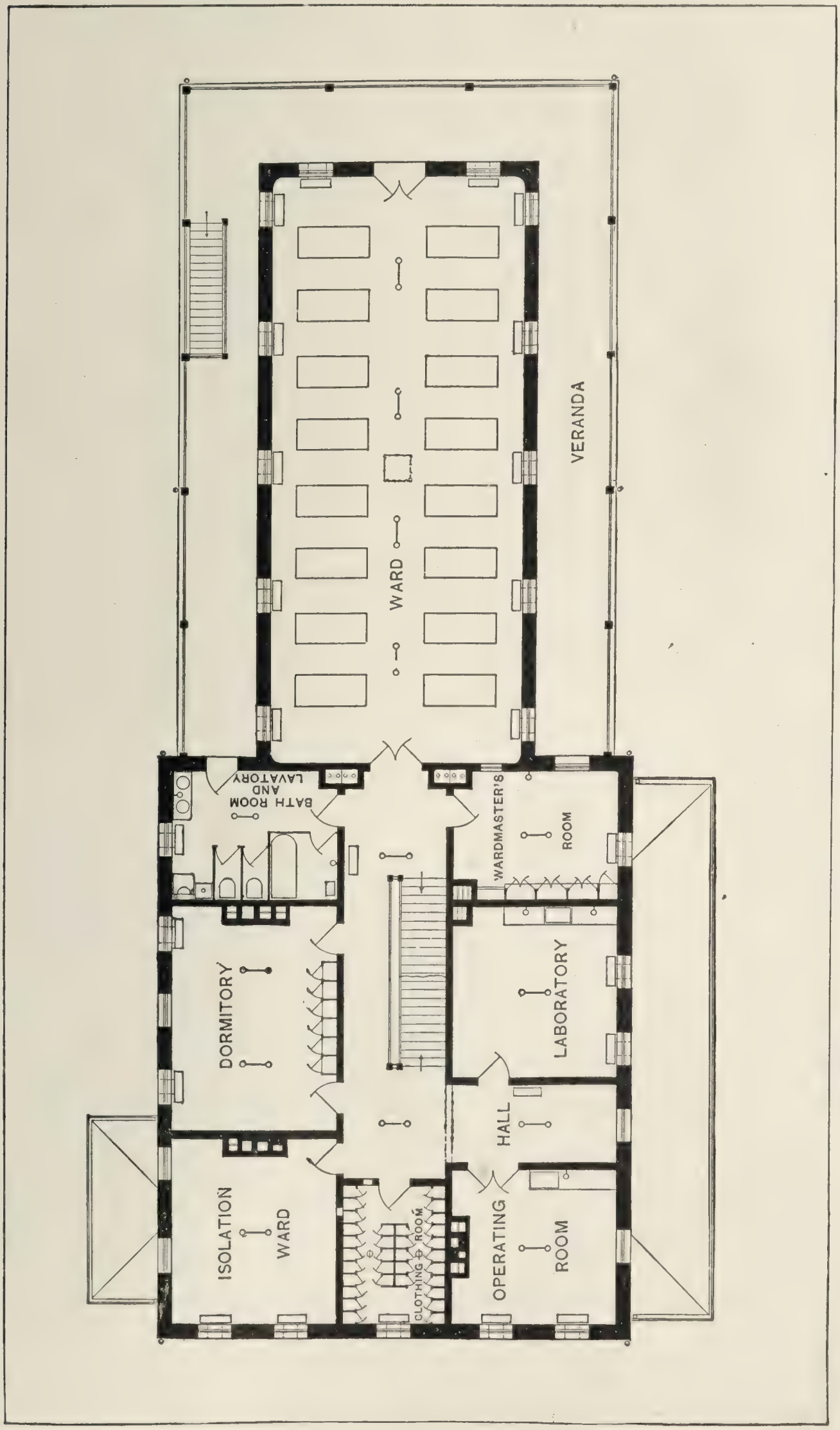


FIG. 206.—Second Story Plan of United States Army Post Hospital at Fort Snelling, Minnesota.

of enamelled iron are now manufactured for ward use, and these should be supplied throughout our service. One chair to each three beds will usually be sufficient. Curtains and bed canopies, still in use in some foreign military hospitals, are of course totally unfit for use in buildings where the sick are cared for. Colored bedspreads should not be allowed; those used should be of white material and be frequently washed. The wooden bed-screens covered with hollands, in use in some of the older hospitals, should be abandoned. The frames of such screens should be of enamelled iron, and these should be covered with ordinary sheets, maintained in a state of absolute cleanliness. The wooden bed-trays, still in use, should be replaced by those of light enamelled metal. Floors should be wiped daily with damp cloths moistened in a solution of mercuric chloride. The cocoa-fibre matting, used until recently, has wisely been discarded. The rubber matting now issued in its place should be wiped down with the solution at the same time as the floor. It should be frequently moved from its place for cleaning, since dust collects beneath it. Walls should be wiped down with a disinfecting solution at least once a month. If the number of sick permits, the wards of a hospital should be used alternately, changing every month. The ward so vacated, with its contents, should be disinfected with formaldehyde and then aired for several days after the removal of the patients. The disinfection of operating-rooms with formaldehyde, after each operation on a case presenting septic conditions, is indicated. All patients should, if possible, be bathed before being admitted to a ward. Their clothing should be taken from them and disinfected before being stored away, and their underclothing should be washed at once. Pajamas or night-shirts, according to the case, should be supplied from the hospital equipment. All bed-linen should be changed twice weekly, and oftener if soiled. Blankets, bed-spreads and mattresses should be frequently sunned.

In time of war, the ordinary hospital accommodations of an army in the field are quite insufficient to meet the demands upon them; and many of the hospitals in garrisons, scattered throughout the country, will not be available for use. Many sick and wounded will be treated in movable field hospitals, but a large proportion of the more serious cases, not immediately fatal, will ultimately reach the more permanent establishments required in base or general hospitals. All modern sanitarians agree that where large numbers of the sick must be treated, the use of independent pavilion wards is far preferable. In civil life, large massive hospital buildings are giving way to small detached sections, and in the military service the advantages of the latter arrangement are even greater. Such buildings are cheap and readily put up. Regarding the pavilion as the unit of hospital construction, any enlargement of accommodation is readily accomplished by the addition of such number of pavilions as may be required. If these become old or infected they may be readily burned without great expense; and in certain civil hospitals in this country it is contemplated that the wooden pavilion isolation wards shall be destroyed by fire every ten years. Pavilions are open on all sides to air and sunlight; and being comparatively small, the danger of any extensive epidemic occurring in a hospital is averted. They are particularly adapted to the shelter of convalescents and wounded, since there are no stairs to interfere with entrance and egress.

When properly laid out, a hospital composed of such wards is easy of administration. All the main buildings should be reached by covered passages, open at all sides, for the protection of the hospital staff and convalescents during hot or stormy weather.

The general arrangement of pavilion hospitals varies greatly. During the Civil War a number of different ground-plans were devised; but, in many of these, sightliness and convenience of administration apparently

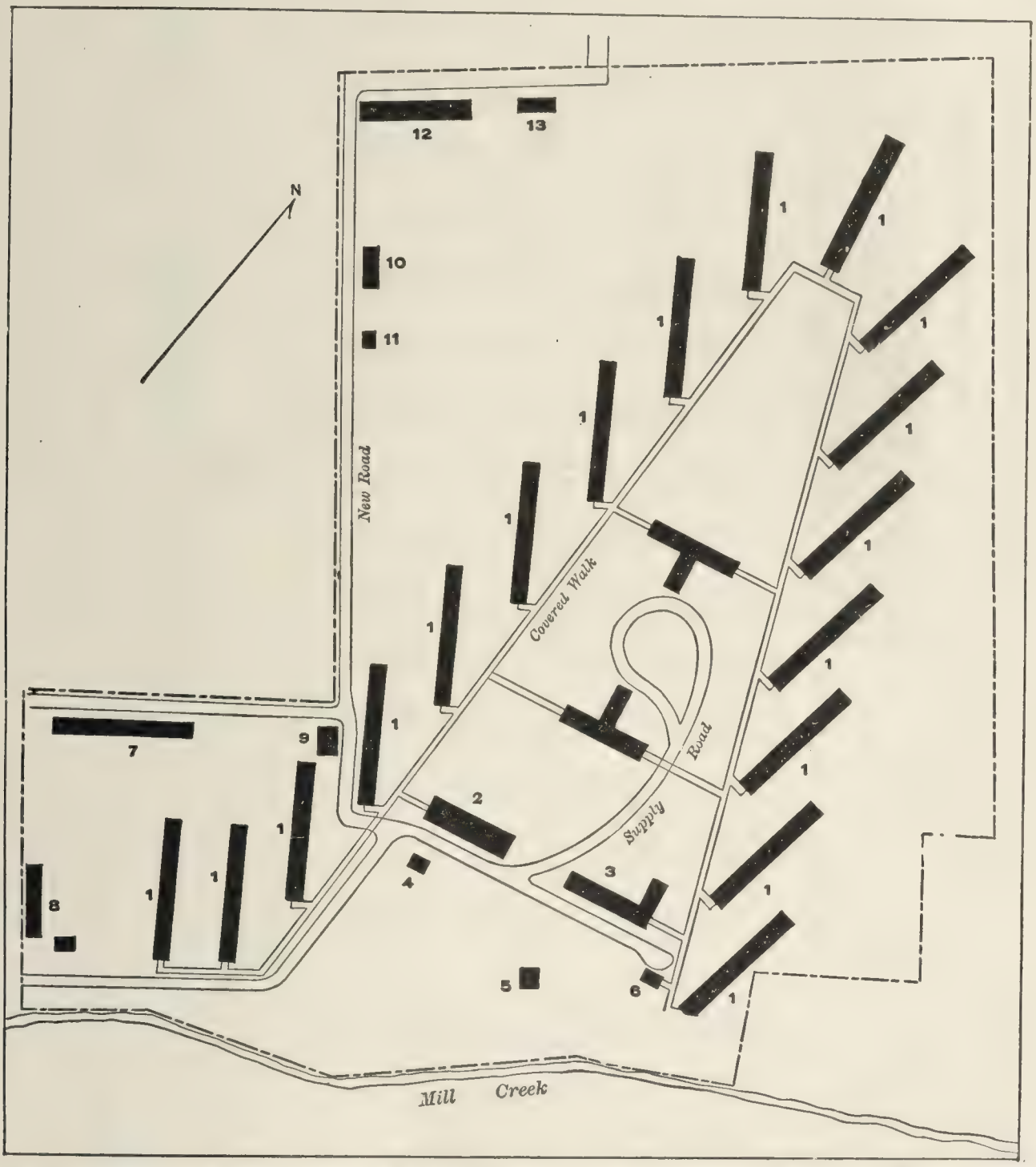


FIG. 207.—United States Army General Hospital, Fort Monroe, Virginia. 1, Wards; 2, administration building; 3, officers' quarters and mess; 4, guard house; 5, commanding officer's quarters; 6, operating-room; 7, female nurses' quarters; 8, laundry; 9, pump-house; 10, chapel; 11, dead-house; 12, store-house; 13, stables. The unnumbered buildings in the enclosed space are mess-halls.

received more consideration than did sanitary matters. At present there are three arrangements which are commonly used in our own and foreign armies. These consist in locating the wards on the outer side of a covered way, shaped like an inverted letter V; in establishing them on two sides of a central square; and in arranging them in two parallel lines on each side of a central covered passage-way.

The general hospital at Fort Monroe is built in the form of an inverted V; similar to the plans of the Lincoln and McClellan hospitals as used during the Civil War, and the hospitals used by the French at Metz in

1870–71. The administration portion of the hospital is located between the two converging covered ways; the wards standing obliquely away from the latter in such a manner as to receive the full benefit of wind and sun

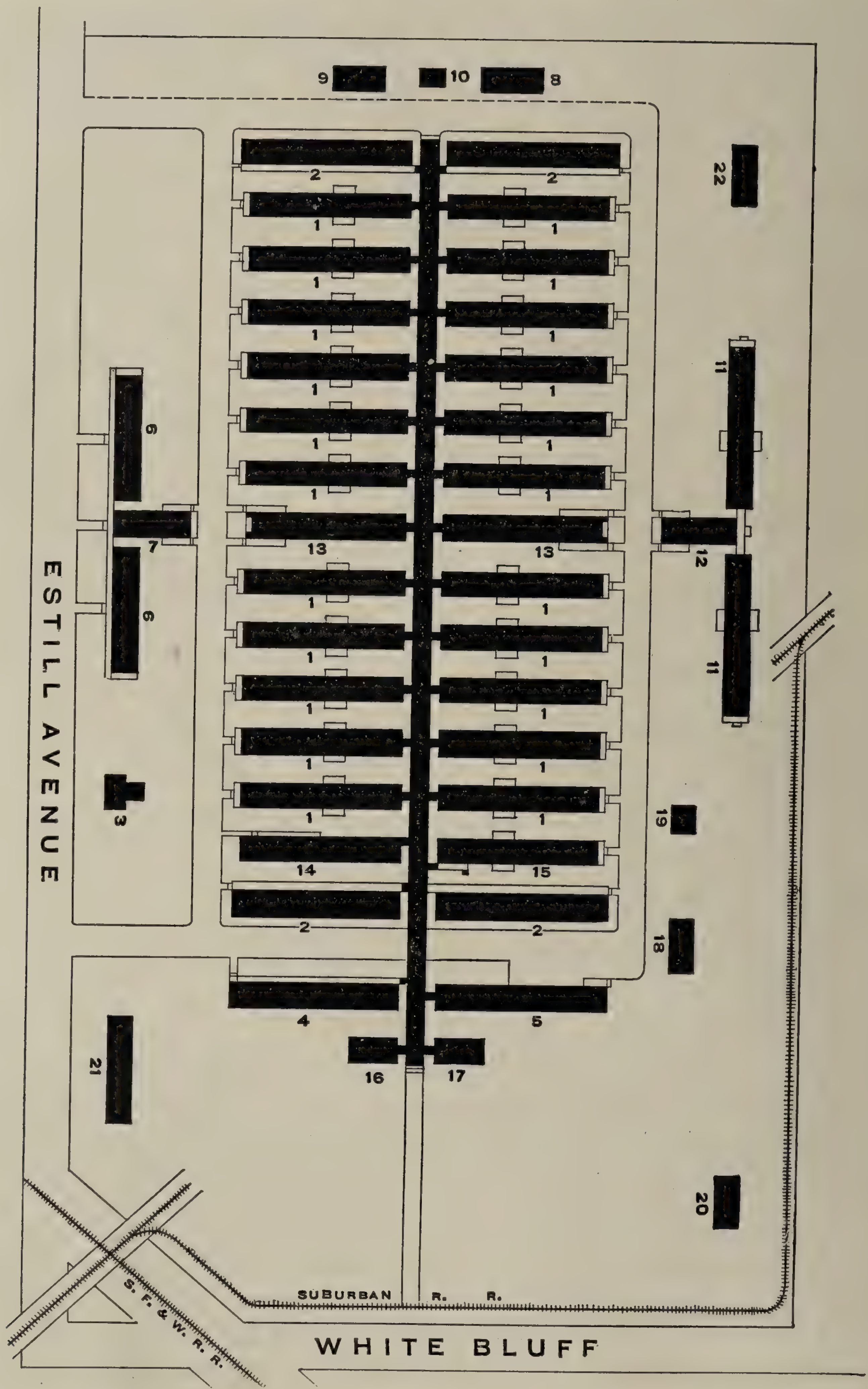


FIG. 208.—Plan of United States Army General Hospital at Savannah, Georgia. 1, Wards; 2, nurses' quarters; 3, commanding officer's quarters; 4, administration building; 5, store-house; 6, officers' quarters; 7, officers' mess; 8, chapel; 9, guard-house; 10, dead-house; 11, hospital corps dormitory; 12, mess-hall, hospital corps; 13, mess-hall and kitchen for patients; 14, dispensary and store-house; 15, operating-room and ward; 16, library; 17, officers' club; 18, bakery; 19, engine-house; 20, ambulance stable; 21, fuel shed; 22, shops.

without interference with each other. The wards are all properly oriented, in this arrangement, and there is no crowding. There are seventeen pavilion wards, which are expected together to accommodate one thousand patients. The buildings are of rough construction and were originally roofed with tarred paper. Later they were shingled. The chief disadvantages of this hospital are difficulty of administration and a too great size of the individual wards.

The general hospital at Savannah, also having a capacity of one thousand beds, is well planned and arranged for purposes of administration; the wards being set at right angles from, and close to, a long central corridor. The long axes of the pavilions, however, run north and south, which is quite undesirable in hospital buildings in such a southern latitude. The buildings are also too much crowded together, and seriously interfere with each other in respect to air currents. The space covered by the hospital pavilions allows but 360 square feet per bed, and the wards are located but 35 feet apart. This gives much too small a ground area. Great importance is attached by all sanitarians to an abundance of free air space about hospital buildings; and, as illustrating this point, Stevenson and Murphy give the following figures with reference to the size of the hospital site, as compared with the number of patients, in a number of the best modern hospitals.

	Approximate area of site, per bed, in square feet.
Germany.	
Friedrichshain	1,713
Tempelhof (military)	1,308
Moabit	1,144
University, Halle	1,575
University, Heidelberg	1,070
France.	
Bourges (military)	1,600
St. Eloi	1,615
St. Denis	1,685
Belgium.	
Antwerp	1,126
United States.	
Johns Hopkins	1,679

Mouat recommends a zone of aëration about each hospital building at least double its height, and modern practice tends to go even beyond this limit. In the military service, where the cost of land is generally not a consideration, the slightly increased facility of administration gained by bringing buildings closely together by no means counterbalances the sanitary disadvantages of overcrowding.

The general hospital at San Francisco, with accommodations for 600 patients, occupies a space 662 by 594 feet and provides a hospital site of 660 square feet to each patient. There are ten general wards. Each ward has an inside length of 153 feet; and, including lavatory and administration rooms, of 180 feet. The width of each ward proper is 25 feet; the space between them 35 feet. These buildings are located in parallel lines on each side of a central square, in which are the operating-room and mess-halls. This square is partially closed in at one end by the adminis-

tration building. It is bordered by a covered passage connecting all the wards, and also bisecting the central square. The plan of this hospital is very similar to that of the Lariboisière, in Paris. It is very convenient, well planned and easily administered, and probably represents the best type of arrangement for pavilion hospitals.

Pavilion wards, in civil communities, are built in a number of forms. For the military service that of a simple parallelogram is employed; the hospital complete costing at the rate of about one hundred dollars per patient. The interior arrangement of these wards varies slightly in our service, but the plan as used for the pavilions in the general hospital at Savannah may

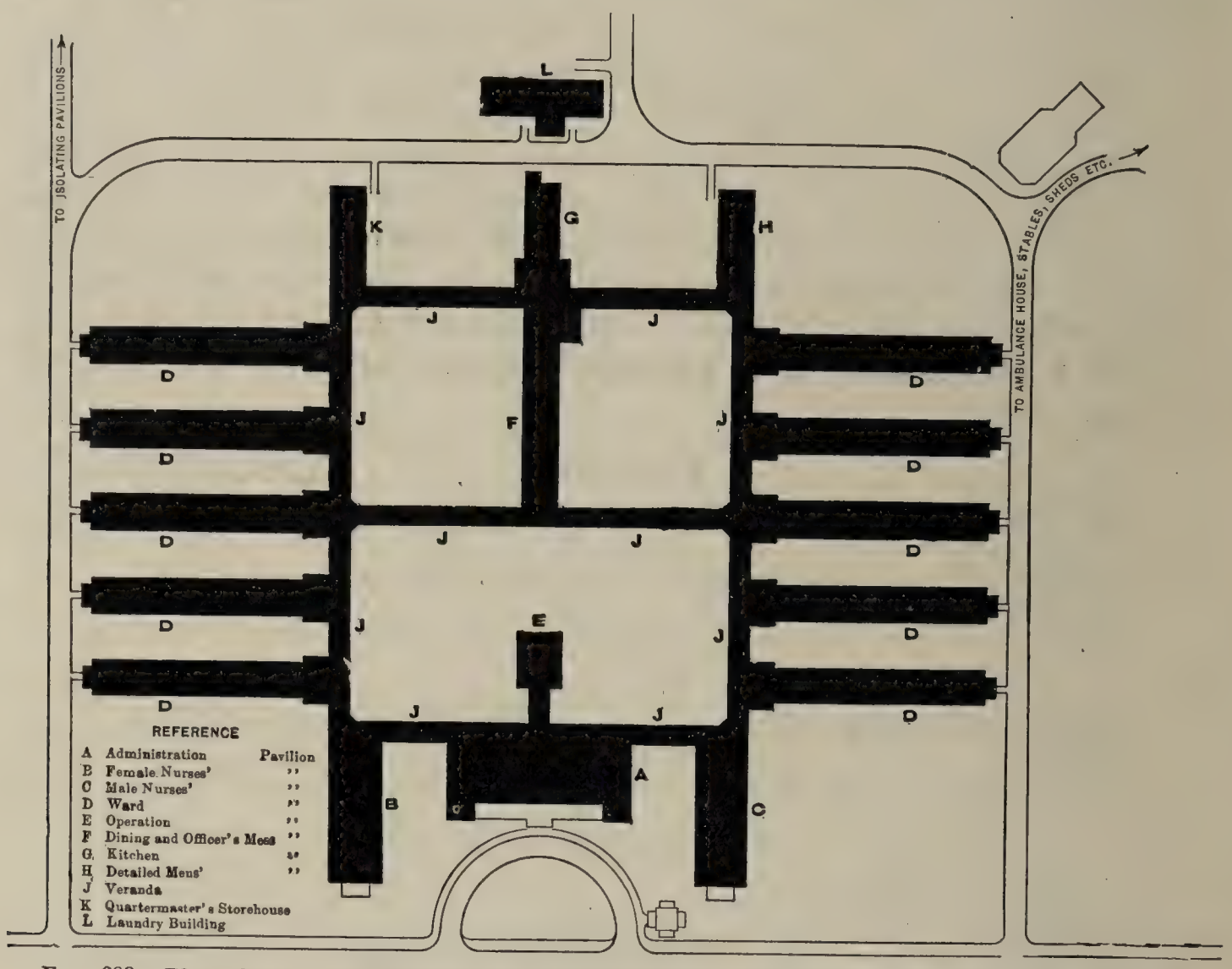


FIG. 209.—Plan of the United States Army General Hospital at the Presidio, San Francisco, California.

be considered as fairly representative of all. This pavilion ward is a frame wooden structure, with double doors at each end and at the centre of each side. It is weather-boarded outside and wainscoted inside. The portion occupied by patients is 92 feet long and 23 feet broad, contains 40 beds and allows 53 square feet per man. The height is $10\frac{1}{2}$ feet, and the cubic air space per patient is 556 cubic feet. In addition to the ward, within the same walls there are nurses and ward-masters' rooms, lavatories and bath-rooms, water-closets and store-rooms. These pavilions present a number of serious disadvantages from a sanitary standpoint. The floor space per patient should be more than twice as much as is actually provided. In the British military hospitals, 100 feet of superficies is allowed to each patient, and Notter and Firth regard 120 square feet per bed as the minimum for hospitals. Some of this space may be gained by widening the present pavilion building by two or three feet. The cubic air space provided

per bed is also much too low; being 44 cubic feet less than the amount the healthy British soldier is entitled to receive in barracks, and but 46 per cent. of what is officially allowed (1,200 cubic feet) to each patient in hospital in the same service. Notter and Firth place the amount of air space which should be provided in general hospitals at 2,000 cubic feet per bed, or nearly four times the amount furnished by our pavilion wards. That serious results have not followed this deficiency in air space is due to the fact that these hospitals have never been filled to their fullest capacity, and are also located in climates in which the windows and doors may be kept open a large portion of the time. The height of these pavilions should be increased to 12 feet. The beds are also too crowded, having an allowance of but 5 feet 7 inches of running wall-space, where all authorities demand $7\frac{1}{2}$ to 8 feet per bed as a minimum. The windows should be made larger, and be carried up higher toward the ceiling. Rooms for nurses and ward-masters attached to a large general ward are quite unnecessary. Nurses should not be allowed to sleep in close proximity to the sick, and when attendants who have been on duty during the day are relieved they should leave the pavilion entirely. The wards themselves, with accommodations for forty patients, are too large. Not more than twenty-four sick should be brought together in any one ward; and in the newer civil hospitals, the wards are usually intended to hold about sixteen sick. It is distinctly an element of danger to the individual patient if he is one of a large number of diseased persons brought together within the same four walls. The water-closets, bath-room and lavatory should be placed in an annex at the rear of the ward, separated by a roofed and latticed lobby, so that odors cannot penetrate into the ward. There should be the most complete severance of atmospheric communication between the annex and the main building; the latter thus containing merely the main ward and two small store-rooms at the end toward the lavatory. There should be no plumbing in the ward building. Wainscoting should not be used, as readily becoming infected. If the build-

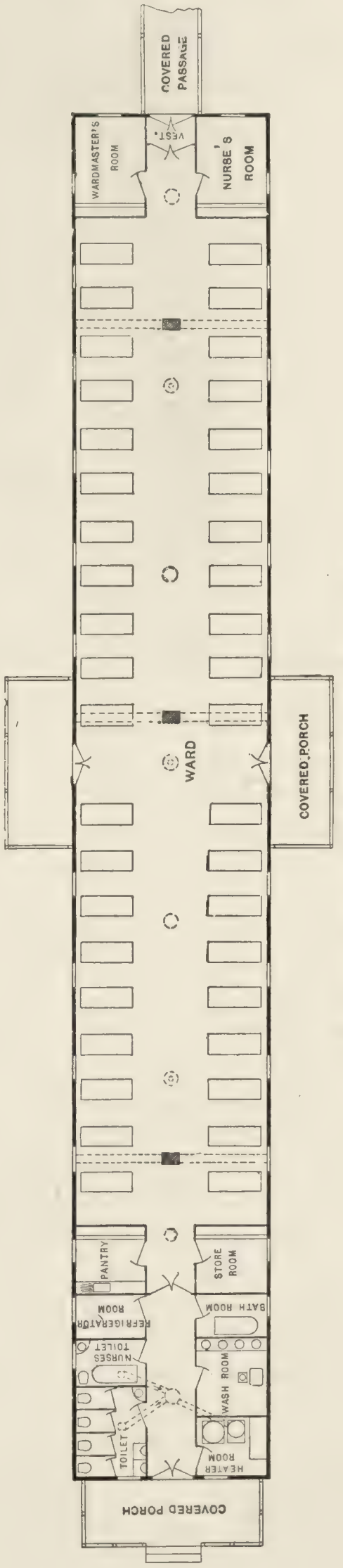


FIG. 210.—Plan of United States Army Pavilion Ward.

ings are too light in structure to allow the use of plaster, some one of the many composition boards now on the market should be used in large panels for the inside finish, and thoroughly gone over with shellac. An open fire-place at each end of the ward, to replace two of the heating stoves at present used, would add much to cheerfulness and greatly improve ventilation. The latter is a matter which deserves the greatest consideration, and which is by no means sufficiently provided for in these pavilion wards. The floor space required depends largely upon the means of ventilation adopted; and, with us, both are at present inadequate. For hospitals, nothing is more certain than that an abundance of fresh air must be provided. During the Civil War it was found that wounded treated in tents or loosely-built huts, through which the air freely passed, had little septic disease; while in permanent hospitals, or houses temporarily converted for the purpose, the so-called hospital diseases were of frequent occurrence. Since a hospital is a building which is perpetually producing within itself the elements of danger to its own inmates, it should be fully understood that the roughest shelter which admits of a through current of air is better than a permanent structure without adequate means of ventilation. Smith and Young, in emphasizing the fact that cubic space is of little value unless it is accompanied by ample means of ventilation, give an instance of the Franco-Prussian War in which it happened that, at about the same time, a church and a slaughter-house in Paris were turned into wards for wounded soldiers. Among the wounded in the church, gangrene broke out and the mortality was very heavy; in the slaughter-house no septic disease appeared, and the men made good recoveries. This happened in spite of the fact that the cubic space per man in the church was greater than in the slaughter-house; but the latter was a mere shed with sides of louvred boards, and the men were practically in the open air, while in the church the wall was solid and the openings were small and few.

The necessity for an almost unlimited supply of air governs hospital construction.

Occupancy of New Buildings.—To fix the time when barracks or other permanent buildings of recent construction may be safely occupied, the climate, exposure, nature of material employed and manner of construction must be considered, since all have relation to the question of dampness. During the erection of a building the materials of construction absorb much water. Bricks, which readily take up water to the extent of ten to twenty per cent. by weight, part with moisture equally readily. The same, however, is not true with respect to plaster and mortar, which do not readily give up the moisture they may have absorbed. According to Flügge, mortar used in building construction contains about 14.8 per cent. of water by weight, and 26 per cent. by volume. Plaster absorbs 50.9 per cent. of its volume of water; and the same author states that in ordinary masonry walls, water is present in the proportion of 13 to 23 per cent. by volume. Pettenkofer calculated that in the masonry of a typical house built of 100,000 bricks, there were 10,000 gallons of water which must be removed before the building would become healthful. Since air at a high temperature takes up a much greater proportion of moisture, he showed that the necessary drying could be accomplished in about one-twentieth of the time if the building were well ventilated and heated.

From these facts it can readily be understood why a barrack occcupied immediately after completion, and without waiting for the walls properly to dry, should be cold, damp and dangerous to health. For this reason, fires should be maintained in as many rooms as possible, and drying air currents thus established throughout the building, as soon as plastering is completed.

It is a difficult matter to determine the minimum time in which a newly-erected building becomes properly habitable. If the walls are still damp they are cold to the touch, and on percussion a dull note is given off quite different from the clear resonance given by a dry wall. Undoubtedly the best method of determining the dampness in new walls, and hence the propriety of occupation, consists in detaching fragments of plaster, which should be weighed, dried at 110° C. and weighed anew. Laveran states that ordinary wall plaster should not contain more than 20 to 22 per cent. of moisture. As long as this proportion is exceeded the building should not be occupied.

CHAPTER X.

VENTILATION.

THE term ventilation appears to be not infrequently confused, in the minds of line officers, with aëration. In simple aëration of a squad-room the air is changed but once or at intervals, whereas in true ventilation the air is constantly renewed by the passing out of a portion of the enclosed air and the entrance of a fresh supply to take its place. Regarded, therefore, as the continuous and more or less systematic renewal of air in a room or other enclosed space, the term ventilation may be strictly defined as the removal or dilution, by a supply of pure air, of the pulmonary exhalations of soldiers, the effluvia which proceed from their persons and clothing, and the products of combustion from lights and fires. Involving, as it does, the introduction and diffusion of pure external air in continuous currents, and the constant removal of a corresponding volume of air more or less fouled by gases, vapors, moisture and particulate matter, or which is warmed above the degree consistent with comfort and health, the subject of ventilation is clearly one of some complexity, and for the military service is closely connected with the production and distribution of heat. It should be understood that the fresh air introduced in ventilation is not necessarily cold air; in fact the practical success of the system will, in many cases, depend upon the entering air being warmed.

The theory of ventilation depends on a few well-known physical laws, simple in themselves but often somewhat difficult of practical application —so that unsatisfactory results even with apparently good methods are not rarely obtained by the inexperienced. While these physical laws are capable of general application, the local conditions met with are so variable that the ventilation of each barrack building and squad-room must properly be considered as a separate problem. Undoubtedly the most exact method of ventilation depends upon the propulsion, by mechanical means, of a definite amount of air during a given period; but the expense of installing and operating the necessary apparatus, and more especially the constant attention which it must receive, create serious objections to the use of this method in the military service. Reliance is therefore to be had upon the ventilation brought about by the diffusion of gases, the inequality in the weights of cool external and warm internal air, and by the movements of external air currents. While perfect ventilation would ensure that none inhaled air which had previously been respired by the man himself or by another, it is obvious that such conditions are not attainable in barracks; and that all which can be expected is the maintenance of the contained air in a state of relative purity, and within the limits fixed by sanitarians as denoting an amount of vitiation in excess of which the systems of those exposed to its influences may be expected to suffer.

Influence of Ventilation upon Health.—In the military service, the injury inflicted upon troops by requiring them to breathe air contaminated with respiratory impurities and deficient in oxygen is usually not perceptible until after a considerable period of time, and is then often attributed to other causes. Though operating in this insidious manner, the evil results of deficient ventilation are none the less positive—as is well shown by comparison of statistics for bodies of men living in ventilated and unventilated habitations, and by the diminution in the rates for sickness and death, in foreign armies as well as our own, which in the past has followed improvement in the ventilation of barracks.

When moderately vitiated air is breathed continuously for considerable periods, even if it does not necessarily by itself originate disease, it certainly lowers the powers of vital resistance and thus predisposes to sickness. Under such circumstances the individual becomes pale and partially loses his appetite, and after a time declines in muscular strength and mental spirits. The oxygenation and nutrition of the blood appear to be interfered with, and a condition of anæmia is often noticeable. Where the air is rendered extremely impure by respiration, it is commonly rapidly fatal to those required to breathe it. Instances of this promptly fatal effect of highly vitiated air are seen in the well-known cases of the "Black Hole of Calcutta," when 123 out of 146 Europeans, held as prisoners by the Mutineers, died in the space of about twelve hours; and of the close prison in which 260 out of 300 Austrian prisoners of war, confined after the battle of Solferino, died in a short time. The poisonous agencies which probably bring about this sequence of events appear to be a deficiency of oxygen coupled with an excess of carbon dioxide, though the symptoms are not those of pure asphyxia. If the persons survive, a febrile condition is usually left behind which lasts three or four days and is often followed by boils and other evidences of affected nutrition.

The former great prevalence of pulmonary tuberculosis, in nearly all European armies, was considered by the commission appointed to investigate the sanitary condition of the British army to be chiefly dependent upon the lack of proper ventilation of barracks. Notter and Firth state that while a great amount of phthisis has occurred at all the stations of the British army, even those with the best climates, "there has been of late years a most decided decline of phthisical cases in these stations, while the only circumstance which has notably changed in the same time has been the condition of the air." Not only may phthisis be considered to have one of its chief predisposing causes in the breathing of an atmosphere deficient in oxygen and highly contaminated by respiration, but other throat and lung diseases—as bronchitis, pneumonia and tonsillitis—appear also to be much more common under such circumstances. As an instance, the medical officer at Fort Douglas, in 1898, reported an immediate decrease in the number of cases of tonsillitis among the troops at that post, on installing suitable arrangements in the previously improperly ventilated barracks. There is no doubt, also, but that the constant breathing of a confined and vitiated air, in addition to the production of an impaired state of health which renders invasion by any infectious disease especially liable to occur, particularly favors the spread of the exanthematous fevers. So well are the above facts recognized that the best authorities now insist

that, if a choice be required to be made between the two, warmth must be sacrificed to some extent in order to obtain a proper amount of fresh air. The influence of pure and impure air on health and mortality is even better shown in the case of horses than among men, since in the first instance the problem is much simplified by the absolute similarity, in different periods or places, of the conditions of food, water, exercise and treatment. It is therefore of interest to note that in the French army the mortality among cavalry horses, in times past, was enormous—Rossignol stating that prior to 1836 the mortality of the public animals in that service varied from 180 to 197 per thousand annually. The enlargement of the stables, with the provision of an increased amount of fresh air, has reduced the loss at the present day to 24.2 per thousand.

The necessity for free ventilation is greater in hospitals than in barracks. The air of a sick ward, unless properly renewed, is well known to be most unfavorable to health; and by deficient ventilation of hospitals the severity of many diseases is increased and convalescence is greatly retarded. This appears to be true of all diseases, but especially so of the febrile affections. Hospital wards, also, are occupied all the time; deficiency in respect to fresh air operating continuously, and not, as is the case with healthy soldiers in barracks, for but a portion of the twenty-four hours.

The benign influence upon health of proper ventilation and an abundance of fresh air appears to be manifested in three ways. First—by diluting the noxious products of respiration beyond those limits of concentration within which they exert a known unfavorable influence upon the human organism. Also the supplying of the necessary oxygen without its admixture with impurity. Second—the fact that moving bodies of air, usually warmed, are great drying agents, and that barracks will not be damp when properly ventilated. Third—the fact that currents of fresh air are of great importance in assisting the destruction of bacterial life by the solar rays. Recent experiments have shown that bacilli exposed to free air currents and the solar rays were killed in two hours, while those exposed to sunlight but which were shielded from air currents survived much longer.

Ventilation in the United States Service.—The conditions in respect to ventilation, in the greater number of barracks in our service, must be regarded as unsatisfactory. In the older established garrisons, many of the habitations for the men were constructed without proper arrangements for the renewal of air; reliance being apparently had, in many instances, solely upon natural means of ventilation. The necessity for special arrangements and devices to assist the movement of air appears to have been strangely overlooked; and it is true that even as late as 1890 buildings for the shelter of soldiers were erected without means of artificially renewing the air within them. In one instance, in that year, the defect was so noticeable as to call for special inspection and report—the latter concluding that the attainment of even fair ventilation of the building as constructed would require considerable additional expenditure. From Fort Robinson, in 1895, it was reported that, save in one instance, not a single one of the barracks at that post had any provision for ventilation except windows and doors; and that these, from the coldness of the climate, must necessarily be kept closed a considerable portion of the year.

In a number of the older barracks, in the construction of which the question of ventilation was not wholly disregarded, or in which an effort was subsequently made to install ventilating arrangements, the matter was often not properly approached. Particularly was the fact often lost sight of that air will not pass out of a room unless arrangements are provided for its admission in proportionate volume, and that it will not enter unless a corresponding proportion of the contained air be removed. Hence, in our service, even at the present time, sanitary reports show that in many cases outlets have alone been provided—the room, with its doors and windows closed, thus having the character of the ventilation which might be found in an uncorked bottle—while in other cases sufficient provision has been made for admitting fresh air, but no means of escape arranged for that which is vitiated. It is true that where such a single opening is provided, double currents, moving inward and outward, are established; but under such circumstances friction is great unless the opening be very large, and the currents are always feeble and may so oppose each other as even to prevent all movement. Special apertures for the entrance and egress of air should therefore be provided; and it may here be remarked that the practical necessity for this is shown by a very simple experiment (Fig. 211). If a lighted candle be placed in an open wide-mouth bottle the flame is soon extinguished. If the air be renewed, the candle again lighted and the mouth of the jar be closed by a stopper pierced with two holes, each containing a glass tube, but of unequal length, the flame continues to burn brightly. The partial closure of one of these tubes, B, causes the flame to diminish in size; and on the complete closure of the tube it dies out.

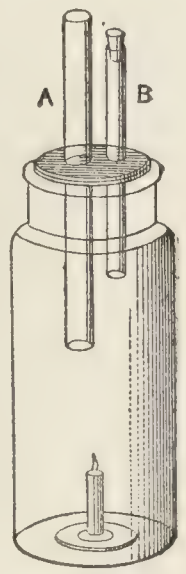


FIG. 211.

In some of our barracks, intended outlets have been cut through into lofts and garrets, while these spaces have not been provided with ventilating shafts leading into the open air. Under such conditions it is obvious that there is no ventilation. Even in some of our barracks of latest construction, provided with ventilating flues, properly located and of sufficient size, these have been made, by some strange oversight, to discharge directly into the loft under the roof. It is true that outlets for this space were also provided—but the undesirability of converting the highest space in an inhabited building into a mixing reservoir for foul air and the dust which it carries, often of an infectious nature, should certainly be apparent to all; particularly in view of the fact that the danger is always present of having this foul air and some of the dust carried back into the squad-rooms by reverse currents. It should be an invariable rule that each squad-room should be ventilated separately, yet this has not always been done. In many instances also the openings provided have been entirely insufficient in size for the work which they were expected to perform; and further, the improper location of such ventilating openings as were provided has not rarely been made in the past. That defects of the above character are so commonly seen furnishes a strong argument for the submission of all working plans for barracks, before any buildings are erected on their lines, to the authorities of the Medical Department. The mistake is too frequently made, in our service, of considering that persons with-

out any special knowledge of sanitation are properly fitted to decide on matters which, like that of ventilation, are purely sanitary.

Vitiation of Air.—In considering the nature and the amount of the impurities added to air by respiration, it is of advantage to contrast the percentage composition of ordinary air with that which has been expired, in respect to their chief constituents. These are as follows:

	Ordinary air.	Expired air.
Oxygen	20.96	16.40
Nitrogen	79.00	79.19
Carbon dioxide	0.04	4.41

From this it will be seen that the expired air contains over one hundred times more carbon dioxide, nearly five per cent. less oxygen, and a small amount of nitrogen more than the atmospheric air. Hence during respiration more oxygen is taken into the body from the air than carbon dioxide is given off; so that the volume of the expired air is from one-fortieth to one-fiftieth smaller than the volume of the air inspired, both being calculated as dry, at the same temperature and pressure. This diminution of the volume of the expired air is, however, far more than compensated for by the warming which the inspired air undergoes in the respiratory passages, so that eventually the volume of the expired air is really one-ninth greater than the air inspired. The relation of the oxygen absorbed to the carbon dioxide given off is as 4.57:4.38. This is expressed by the so-called respiratory quotient:

$$\frac{CO_2}{O_2} = \frac{4.38}{4.57} = 0.905$$

An average adult gives out at each respiration 22 cubic inches of air, and, assuming that he breathes eighteen times a minute, the total quantity of air which passes out of the lungs in the twenty-four hours is thus 570,240 cubic inches, or 330 cubic feet. If it be further assumed that the expired air contains 4.4 per cent. of carbon dioxide, the average adult at rest evolves 14.52 cubic feet of this gas in the twenty-four hours, or 0.6 of a cubic foot per hour. This amount of carbon dioxide will be increased by body activity and varies also with the weight of the individual; it may, in the case of a man doing hard work, reach 37 cubic feet in the twenty-four hours, implying an hourly elimination of carbon dioxide of 1.6 cubic feet. For soldiers living under the usual conditions found in squad-rooms, the carbon dioxide given off from the lungs is generally accepted as about 0.72 cubic feet per hour. Pettenkofer, whose experiments are perhaps the most trustworthy, ascertained that a man twenty-eight years of age, weighing 132 pounds, evolved 0.56 of a cubic foot of carbon dioxide per hour at night, during repose, and 0.78 in the day time under very moderate exertion; during hard work the same man evolved 1.52 cubic feet per hour. These amounts give the following:

In repose	0.00424	cubic foot of CO_2 evolved per pound of body-weight.
In gentle exertion.	0.00591	" " " " " " " " " " "
In hard work	0.01152	" " " " " " " " " " "

These figures, though based upon an individual of considerably less weight than the average soldier, are nearly in the ratio of 2, 3 and 6—and

this may serve as a guide to the proportions of fresh air required under different conditions.

Since ordinary unrespired air contains an average of 0.4 parts of carbon dioxide per 1,000, it is obvious that any excess beyond this amount implies vitiation. In a closed and occupied space a certain amount of impurity must always be present in the air, and it thus becomes important to determine the permissible limits of such impurity. This has been fixed by de Chaumont and others at 0.6 parts of carbon dioxide per 1,000, or 0.2 parts in excess of that already present in the atmosphere, and this standard is now accepted by all sanitarians. It is based upon the observed fact that when the respiratory carbon dioxide exceeds this proportion, the air in the room begins to smell close and fœtid. Having established a standard as to the respiratory impurity which may be regarded as permissible, it becomes easy to calculate the amount of fresh air needed properly to dilute the air expired by the soldier during a given time, so that the carbon dioxide contained in the resulting mixture shall not exceed the permissible limits.

As compared with the standard of respiratory impurity given above, the air of barracks usually shows a high degree of vitiation—less so in the newer and better ventilated buildings. At Fort Robinson, in 1895, the barracks being unprovided with ventilation facilities, the amount of carbon dioxide found in eight squad-rooms ranged from 1.334 to the very high proportion of 2.600 parts per 1,000. In England, a large number of analyses of the air in barracks was made by de Chaumont, the amount of carbon dioxide in the external air being simultaneously determined. The cubic air space allowed per man was 600 cubic feet. Typical results obtained by him were as follows:

	CO_2 in external air.	CO_2 IN ROOM.		Mean respiratory impurity in CO_2 in excess of that in external air.
		Largest amount found.	Mean amount found.	
Gosport new barracks	0.430	1.846	0.645	0.215
Anglesey barracks	0.393	1.971	1.404	1.011
Aldershot	0.440	1.408	0.976	0.536
Chelsea	0.470	1.175	0.718	0.248
Tower of London	0.420	1.731	1.338	0.898
Fort Elson (casemate)	0.425	1.874	1.209	0.784
Fort Brockhurst (casemate)	0.422	1.027	0.838	0.416
Aldershot Military Prison, cells	0.409	3.484	1.651	1.242
Gosport Military Prison, cells	0.555	2.344	1.335	0.780

Published analyses of air of prison cells show, in all cases, a very high degree of respiratory impurity, and this is probably one of the chief depressing influences of long cell confinement. Wilson gives some important information on this point. In cells of 614 cubic feet capacity, always occupied, he found the CO_2 to amount to 0.720 per 1,000; the prisoners were healthy and had a good color. In cells of 210 cubic feet capacity, occupied only at night by prisoners employed outside during the day, he found 1.044 per 1,000 of CO_2 and the occupants were all pale and anæmic. While exact figures for our own service are lacking on this point, medical

officers will frequently be impressed with the pallor of prisoners housed in poorly ventilated guard houses, especially in the case of such prisoners as are detailed for considerable periods as room-orderlies. In the limitation of evil results upon health through such constant confinement in bad air, it is clear that the inside work of policing should be performed by the prisoners in rotation, and no one man should be allowed continually to do such work, as is not infrequently the case. Outside labor in the open air is, in practice, a privilege and a benefit to prisoners.

The amount of respiratory impurity in badly-ventilated barracks, as might be expected, increases with length of occupancy. Hence the period of greatest vitiation in squad-rooms will be found shortly before reveille. Leo found the following amounts of carbon dioxide, in a barrack at Alberstadt, at different hours of the night:

Hours.	Parts of CO_2 per 1000.	Hours.	Parts of CO_2 per 1000.
8 to 10	0.86	12 to 2	2.14
10 to 12	1.57	2 to 4	2.48

In spite of its greater specific gravity, there is, in practice, no accumulation of carbon dioxide near the floor of an occupied room, since expired air is warmer and hence lighter than the surrounding atmosphere. Leblanc, Coulier, Pettenkofer and others have shown that carbonic acid is always present in greatest amount at the top of an inhabited space. In a theatre, at the end of a performance, Leblanc found 1.5 parts of CO_2 in air samples taken in the orchestra, and 3.0 parts per 1,000 in air taken in the highest gallery. Laterally, carbon dioxide is equally diffused through the air of a room. It is very rapidly got rid of by opening windows, and in this respect differs from organic matter and probably from watery vapor; neither appearing to diffuse rapidly or equably through a room.

With respect to the direct influence of an excess of carbon dioxide upon the organism, the gas is said by Stevenson and Murphy to produce fatal results when the amount reaches from 50 to 100 parts per 1,000 volumes; while at an amount much below this, usually placed at 15 to 20 parts per 1,000, it produces severe headache. Some persons can inhale without injury, for a brief period, considerable quantities of pure diluted carbon dioxide; and animals can be kept for a long time in an atmosphere highly charged with it, provided the amount of oxygen be also increased. With the air of respiration, headache and vertigo are usually produced when the amount of carbon dioxide is not more than 1.5 to 3 volumes per 1,000; but to this result the undue heat of the room, under such circumstances, probably contributes. The presence of a very large amount of carbon dioxide in the air may lessen its elimination from the lungs and thus retain the gas in the blood—and in time this may produce serious impairment of nutrition.

The same principles which govern the calculation of fresh air, needed to dilute and remove respiratory impurities as indicated by the amount of carbon dioxide present, apply also to the case of air vitiated by gas-lights, lamps and candles. Where the products of their combustion are allowed to pass directly into squad-rooms, as is the case in our service, the impurities added will be considerable, and fresh air should be supplied to

dilute and remove them. For their proper dilution, however, the amount of fresh air supplied, in relation to the carbon dioxide evolved, need not be as great in their case as for breath impurities, since organic respiratory emanations of deleterious character must be considered in connection with the latter. It has been calculated that for every cubic foot of coal-gas burned, 500 cubic feet of fresh air must be introduced hourly to dilute the products of combustion properly; and this is not a high estimate when it is considered that a cubic foot of good coal-gas produces one-half a cubic foot of carbon dioxide, together with a certain amount of sulphur dioxide and other substances. The flat flame gas-burners used in our barracks are calculated to consume 6 cubic feet of gas hourly; and in an evening of four hours one such burner will thus generate 12 cubic feet of carbon dioxide. Assuming that a supply of 1,000 cubic feet of fresh air is required for every cubic foot of carbon dioxide produced in this manner per hour, it is therefore necessary to supply 12,000 cubic feet of air, during the evening, to each regulation gas-burner—or about 3,000 cubic feet per hour. This amount is about equal to that required for respiratory purposes by a soldier in barracks during the same period. Since for a squad-room containing twenty-four men probably six such gas-burners would be necessary, it follows that provision should be made, when gas is burned under such conditions, for the admission of about one-fourth more fresh air than would be required during daylight. These facts abundantly demonstrate the great importance of directly removing the products of combustion by a special channel—a method clearly preferable to the present practice of allowing them to contaminate the air, even if ventilating arrangements capable of providing a greater supply of air, while lights are used, were secured for squad-rooms. Speaking generally, the Welsbach gas-burner uses up only half as much air, the illuminating power being the same, as the ordinary flat six-foot burner. According to Notter and Firth, one pound of mineral oil requires 138 cubic feet of air for complete combustion, and properly to dilute the products of its combustion about 8,000 cubic feet of air are necessary. Since incandescent electric lights contribute no impurities to the atmosphere their use entails no extra provision of fresh air. This quality is a strong argument for the employment of such a means of lighting.

Where barracks are warmed by hot air, hot water or steam, it is obvious that the products of combustion from fuel used in heating will not assist in the vitiation of the air of squad-rooms, nor, with the proper distribution of fresh air to such central heating plants, need the quantity of oxygen required in the combustion of fuel be a matter requiring consideration from the standpoint of ventilation. But where squad-rooms are directly heated by stoves, as is the case in many of our barracks, the subject at once assumes a practical importance. According to Notter and Firth, for the complete combustion of one pound of coal at least 160 cubic feet of air are required by theory; but in actual practice from half to twice as much air must be supplied, making the average amount required per pound of coal to be from 240 to 300 cubic feet. Since so many varieties and sizes of stoves are in use in our service, no general figures as to the amount of fresh air to be supplied to fires in squad-rooms can be given, but knowing the average consumption of coal in any given instance the amount

of fresh air properly to be supplied for purposes of combustion can readily be calculated.

During the burning of coal about one per cent. is given off into the air as soot and tarry products, with large quantities of carbon dioxide and carbon monoxide. Where stoves are in sound condition, and are properally cared for, these impurities should not escape into the room, but should pass out through the chimney into the external atmosphere. In practice, however, these theoretical conditions will frequently not be obtained in barracks. Improperly jointed stove-pipes or stoves which are cracked and broken are not rarely seen, and through the fissures and crevices of such defective appliances the impurities of combustion may escape into the room in considerable quantities. In some forms of stove used in our service, spaces in the doors are closed with sheets of mica. These are often knocked out by careless handling, and their prompt replacement does not seem to be regarded as important by most company officers or quartermasters. Deficiencies of this sort may contribute largely to the atmospheric impurities in the room. In the care of fires, also, the average room-orderly uses little discretion. In very cold weather especially the fires will be maintained at their maximum, and a red-hot stove is considered rather as desirable than otherwise by most soldiers. It has long been recognized, however, that where this overheated condition is present much carbon monoxide may pass through the red-hot iron into the air of the room, this gas being far more dangerous than carbon dioxide. Open fires and grates will rarely be used in our barracks, though they are much employed in foreign services. Fires of this sort are particularly subject to down-drafts, generally due to the amount of air required by the fire being less than that which can, during the same period, pass through the normal inlets in a closed room, whereby a certain amount of fresh cold air endeavors to force an entrance down the chimney. This results in the carrying of much smoke and other products of combustion back into the room. The remedy of course consists in increasing the size of the inlet, which may temporarily be accomplished by partially opening a door or window. Serious faults of this character could never occur in properly ventilated barracks.

From the above it is obvious that while destroying considerable air for the sake of its oxygen, and requiring a special supply to support combustion, certain arrangements for heating may give off, in the air of rooms, when badly constructed or managed, considerable amounts of impurities. The quantity of these impurities is of course very variable.

While the chief need of fresh air is usually emphasized with special reference to the removal or dilution of organic or inorganic impurities, fresh air also plays an important part in the removal of excessive moisture. Watery vapor is given off into the air not only in respiration but also largely by artificial lights; and not a little of the discomfort attending vitiated atmospheres is due to the large amount of their contained moisture. Expired air is practically of the same temperature as the body, and is saturated with water vapor. Consequently any volume of air much vitiated by respiration soon becomes heated air and more or less saturated with moisture. But air which is loaded with moisture transmits, in each unit of time, much more heat than air which is dry. Hence, when air at a

high temperature is saturated with moisture it communicates heat to the body, producing an oppressive sensation; when the temperature of the saturated air is lower than the temperature of the body the transfer of heat is the other way, producing a sensation of cold. A low temperature with a dry atmosphere is therefore more comfortable than a higher temperature when the air is loaded with moisture, for no other reason than that it favors the prompt and regular removal of body-heat by combined conduction and evaporation. Both de Chaumont and Billings have laid special stress on the importance of humidity in connection with ventilation. The former states that an increase in humidity of one per cent. has as much influence on the condition of an occupied space, when judged of by the sense of smell, as a rise of 4.18° F. The amount of water given off to the air by respiration of course varies with the temperature and condition as to humidity of the inspired air, as well as with the size of, and work being done by, each individual; but on an average of twenty-four hours, the amount may be taken as being 10 ounces, or 300 grams, for each adult —to which must be added some 20 ounces more of moisture given off by the skin. If it be assumed that the average temperature of occupied rooms is 60° F., this means that enough moisture is hourly given off by the human body, in repose, to saturate 90 cubic feet of air. It is this tendency to become saturated with moisture from the lungs and skin which makes the air of crowded rooms so uncomfortable. Carnelley's experiments show that for every part of carbon dioxide found in the air, 2.7 volumes—or 1.1 part by weight—of moisture have been given off by each person inhabiting the room. The removal of excessive moisture by a supply of fresh air is thus important.

As is fully appreciated by all officers, poorly ventilated barracks have a distinctive odor of their own, especially strong during the sleeping hours before reveille or on damp days. This odor, markedly perceptible on passing from the outer air into a crowded, illy ventilated squad-room, is made up in part of volatile products of decomposition contained in the expired air of soldiers having decayed teeth, foul mouths or certain disorders of the digestive apparatus, and in part to volatile fatty acids produced from the excretions of the skin, and from clothing soiled with such excretions. To this is usually added the odor of stale tobacco smoke, and also the effluvia given off by the organic matter which is always present on walls and floors. In our newer barracks, from the better means of renewing the air provided of late years, these close, foul odors are much less marked, though they are still very apparent.

The direct and indirect effects of such odors upon the comfort and health of soldiers are probably more considerable than are generally accepted. In a fresh, pure air, the inhalations are instinctively full; if the air be vitiated and foul-smelling the organism is warned through the olfactories and as little air as possible is respired, the oxygenation of the blood being thus interfered with. It is fair to presume that this aversion to the bad odors of vitiated air was intended by nature to serve as a safeguard against exposure to such influences.

In hospitals, from the nature of the conditions often necessarily obtaining in them, the production of odors is more rapid and extensive than in barracks. So much organic substance is thrown off in certain diseases

that scarcely any ventilation is sufficient to remove the odor. In some hospitals, de Chaumont found that there was still a close smell when 5,000 cubic feet of fresh air, and even more, were supplied to each man hourly. In general, and without attempting to demand too much, it may fairly be assumed that the quantity of fresh air to be supplied to every room used for the shelter of soldiers should be sufficient to remove all sensible impurities.

The organic matters contained in expired air are small in quantity. A certain portion is apparently suspended, and is made up of small particles of epithelium and fatty matters derived from the skin and mouth, while another part consists of organic vapor thrown off from the respiratory tract. These organic impurities give rise to the fœtid smell already mentioned as being noticed in badly ventilated barracks; and which often hangs about squad-rooms for so long a time, even after the rooms are well aired, as to show that the odoriferous substances are oxidized slowly. Most hygroscopic substances, and particularly blankets and woolen uniform clothing, absorb and retain these odors with great readiness and tenacity.

The organic matters contained in the expired air have been long looked upon as being in the nature of a volatile poison, but recent experiments tend to oppose this view. The conclusions of Haldane and Smith are to the effect that the immediate dangers from breathing air highly vitiated by respiration arise from the excess of carbonic acid and deficiency of oxygen, and not from any special poison; that any hyperpnœa which ensues is due to excess of carbon dioxide and not in the corresponding deficiency of oxygen, the hyperpnœa usually appearing when the carbon dioxide is present to the extent of from three to four per cent.; that the frontal headache so commonly produced by vitiated air is due to the excess of carbon dioxide; that hyperpnœa from insufficiency of oxygen begins to be appreciable when the oxygen in the air breathed has fallen to a proportion which varies in different individuals. To this must be added the discomfort produced by excessive heat and moisture. With these conclusions most sanitarians are now agreed.

Drafts, and the Rate of Ventilating Air Currents.—To be satisfactory, the renewal of air in barracks should be insensible to the occupants. Cold drafts will not be tolerated by soldiers, and the man who sleeps under a window or near a ventilator will not permit it to be open to his own discomfort, so that those at a distance may have fresher air. Where the ventilating inlets admit cold drafts, the men, unless carefully watched, will invariably plug them up, often with old clothing, gunny-sacks and similar uncleanly articles; so that in cold weather the condition of the intake apparatus as regards perviousness is thus often an excellent guide to the practical efficiency of its operation. Where ventilating inlets are found to be thus stopped up, the sanitary officer need not in all instances at once demand that they be re-opened—in spite of the fact that this action is obviously detrimental to the comfort and perhaps the health of the men—and then consider his duty performed. Under such circumstances, existing arrangements are clearly not satisfactorily accomplishing the purpose for which they were intended, and their practical disadvantages of operation should rather be recognized and efforts

made for their improvement. Often this can be accomplished by screens or other simple means, but in some instances the faults are so aggravated that some of the existing intakes may have to be wholly or partially closed during cold weather and other arrangements made for the proper renewal of air. Any arrangement for admitting fresh air which is obviously defective should not be permitted to remain indefinitely, as is too often the case in our service, but should be remodeled at the first opportunity. In many instances, however, inlets which work satisfactorily under nearly all conditions are temporarily closed by the men during brief periods of windy or severe weather. Under such circumstances the prompt re-opening of the intakes after the emergency is passed, and their maintenance in a pervious condition, is required.

Large rooms are proportionately easier to ventilate without drafts than are smaller ones, a practical argument for supplying an adequate cubic air space to the soldier. Particularly if natural processes are employed, the difficulties of adequately ventilating a small space are considerable. These are caused not so much by the rate of the greater part of the air in a room as by the velocity of the air currents at their point of entrance. If a space of 500 cubic feet be supplied with 3,000 cubic feet of air hourly, through an inlet having an area of 12 square inches, the movement of the entering air would necessarily be at the rate of 10 feet per second, or nearly 10 miles an hour; if the inlet have a sectional area of 24 square inches the rate would be 5 feet per second. In either case, in such a small space, the air could not properly be distributed before reaching the person and a draft would be felt. If instead of 500 cubic feet of space 1,000 be given, the problem becomes much easier, for the small entering air current, in mixing with the air of the room, would be more easily broken up, and the soldier being able to get further from the opening the movement of air is less apparent.

As to the point at which the sensation of draft is noticed, not only the rapidity of the air current but its temperature and the amount of atmospheric moisture must be considered. Air currents having a temperature of 55° to 60° F. and a rate of $1\frac{1}{2}$ feet per second are not perceived. Those having a rate of 2 to $2\frac{1}{2}$ feet per second are perceptible to some, a rate of 3 feet by most persons and that of $3\frac{1}{2}$ by all. Any greater rapidity gives the sensation of draft. If the temperature of the air be about 70° F. a rather greater velocity is not perceived, while if it be still higher, 80° to 90° F., the movement again becomes more perceptible; and this is also the case if the temperature be below 40° F. A cold current of air is most noticeable if its humidity be excessive. From what has been said, it is obvious, in the prevention of drafts, that much of the air admitted to barracks during cold weather should be warmed. This necessity is recognized in the British service, in which it is officially prescribed that one-half the air so admitted shall be previously heated. In our own service, in some of the older barracks, this important point has been overlooked, though in those of late construction it has been provided for. The different methods of warming the entering air are discussed later.

In the prevention of drafts it is also important that entering air shall be broken up into small currents on being admitted to the squad-room, and for this same reason the inlets should be numerous and small.

Drafts rarely occur from outlets, unless their action be reversed by temporary conditions. In some instances, however, where a large ventilating flue runs down to the floor and the outlet opening is near its base, a strong and steady movement of air, uncomfortable to the feet, is established toward it during cold weather. This is often a cause of strong drafts on persons in front of open fireplaces. The remedy for this condition is obviously found in the multiplication of outlets at widely separated points.

Beds should never be placed in front of windows; since even if closed the leakage of cold air around the sashes, and the chilling of the layers of air in contact with the window-panes, may result in descending drafts upon the heads of the sleepers. In general, ventilating intakes should be at points not readily accessible to soldiers, and their operation and control should been trusted to men specially charged with their service. In this way the function of the inlets will not be surreptitiously interfered with, while the existence of any unpleasant drafts will early become known to the proper authorities.

From what has been said it is apparent that the rapidity of entering air currents cannot, with comfort, be in excess of $3\frac{1}{2}$ feet per second unless the air has been previously warmed; though Putzeys believes that no calculations for the admission of air should be based on a rate greater than $2\frac{1}{3}$ to 3 feet per second. This point is all too frequently overlooked in our barracks. The ventilating shafts provided for the renewal of air are often incompetent, under existing conditions, to perform the service expected of them; which service, if actually accomplished, would imply a rate of movement of air ordinarily quite impossible of attainment by natural means, and which would be quite incompatible with comfort or health if it could be secured. Experience has demonstrated that if the amount of cubic space allowed in squad-rooms be so small as to require a considerable number of renewals per hour to dilute the products of respiration down to permissible limits of impurity, the inmates of such rooms are subjected to discomfort from drafts. Even a renewal five times per hour would be too much. In the British army it has been found that, in barracks with 600 cubic feet per head, the rooms are cold and drafty when anything approaching to 3,000 cubic feet of fresh air per head per hour is passing through; that is, a change of five times per hour for each 600 cubic feet of air space. A change equal to three or three and one-half times per hour is generally all that can be borne under the usual conditions of warming in temperate climates, or that is practically attainable with natural ventilation; and if this be correct, assuming the hourly excretion of carbon dioxide by the soldier to be 0.72 cubic feet, 1,000 cubic feet should theoretically be the minimum allowance for the initial air space. In general, the frequency with which air may be changed depends to some extent upon the temperature and degree of moisture in it, whether it is warmed before being introduced, upon the appliances for introducing it and breaking it up, and upon the absolute size of the space to be ventilated.

In connection with the rapidity of air currents, it is important to remember that the influence of friction is very marked in this respect. The amount of loss produced by friction is often overlooked in estimating the size and character of inlets and outlets, and such neglect is apt to lead to

unsatisfactory results and disappointment. The chief causes of loss are the following:

1. Length of tube or shaft. Here with equal sectional areas the loss is directly as the length; so that with a shaft of 30 feet as the standard, a shaft of 40 feet long would have an increased friction of one-third.

2. Size of opening. For similar sections the friction is inversely as the diameter. Thus for two openings, respectively one and two feet in diameter, the friction at the smaller opening will be twice that of the larger. In this way dividing up an opening into a number of smaller ones, the aggregate of which is equal to the original opening, produces a loss by friction in the direct ratio of the diameters. An opening of one square foot divided into four openings, each of $\frac{1}{4}$ square foot, loses in the ratio of $1:\frac{1}{2}$, being respectively the diameters of the openings. When the shapes of the openings are not similar, the ratio may be stated as that of the square roots of the areas. Thus one square foot divided into nine openings, each equal to one-ninth of a square foot, will lose in the ratio of $1:\frac{1}{3}$, the square roots of the respective areas.

3. Shape of opening. A circular opening may be taken as the standard—that being the figure which includes the greatest area within the smallest periphery. The loss sustained from the use of any other shape will be proportionate to its difference from a circle enclosing a similar area. Thus of two openings, each of one square foot area, the one being a circle and the other a square, the length of the periphery of the latter will be four square feet, of the former $3\frac{1}{2}$; therefore the velocity of the current through the square opening will be $\frac{3\frac{1}{2}}{4}$ or $\frac{7}{8}$ of that through the circular opening. This is a point which is completely ignored in the construction of our barracks; the ventilating shafts used, in their transverse section, being invariably rectangular.

4. Angles in the tube or shaft. This is a most serious cause of loss. The exact formula for this has not been distinctly determined, but it may be accepted, as in accordance with experiment, that every right angle diminishes the current by one-half, so that two right angles in a tube would reduce it to one-fourth; and so on. Yet it is no uncommon thing in our service to find tubes and shafts bent at numerous angles to save expense and appearance. If change of direction is necessary, the shaft should be gently curved rather than abruptly bent. The loss of head with a curved or U-shaped bend is only one-half as great as with two rectangular bends.

5. The presence of dust or dirt of any kind seriously interferes with the movement of air. This may of course be obviated with a moderate amount of care and attention, but in practice it rarely is. The gratings on ventilating shafts are often fastened in so securely as to render their removal for purposes of cleanliness extremely difficult of accomplishment without permanent injury to the building. It is advisable generally slightly to widen the openings of shafts, especially if they are of small diameter, as the current tends to be contracted and obstructed at that point, and loss of head results. At every change of direction the same thing takes place. Hence the desirability of rounding-off angles as much as possible, where they cannot be altogether avoided. It is best to have the sections of shafts circular or elliptical instead of rectangular; for not only

is there less loss by friction originally but there is less chance of lodgment of dust and débris, and the shafts can be more easily and thoroughly cleaned.

It must not be overlooked that under certain circumstances the specific gravity of vitiated air, as compared with pure air, may be often as important as friction in hindering ventilation.

Superficial and Cubic Space.—Squad-rooms should never have a height of less than $10\frac{1}{2}$ feet, and a height of $11\frac{1}{2}$ to 12 feet is preferable. Above 12 feet the additional height should not be taken into consideration with reference to the ventilation of barracks, and a height greater than this need not be provided for barracks in temperate climates. Under no circumstances should very high ceilings be allowed at the expense of floor space, under the impression that proper cubic space is thus provided. Excessive height increases cost of construction and heating, and renders the maintenance of cleanliness difficult. It also to a certain extent interferes with ventilation by means of windows; since the great size and weight of the sashes required under such circumstances would forbid carrying the windows close to the ceiling, and an accumulation of stagnant air occurs above their level unless special means for its removal are provided.

Floor space and cubic space are both important factors in the ventilation of barracks. In general, the amount of cubic space required depends directly upon the rapidity with which the air of a squad-room can be changed without discomfort. While an abundance of cubic space is always desirable, the idea is not rarely entertained by line officers that cubic space may take the place of change of air, so that if larger cubic space be available a certain amount of change of air may be dispensed with, or less fresh air required. This view is obviously quite erroneous, since even the largest space can provide sufficient air for a limited time only, after which the necessary amount of fresh air is required to be supplied hourly, whether the space be large or small. In our service, even the latest barracks allow but 56 to 60 square feet of space, per capita, in squad-rooms, and in nearly all old barracks the superficies available per man is far less than this amount—which is about the floor space provided in the British service. Morache regards 100 square feet of space as the proper amount to be supplied to each healthy soldier, but this area appears to be slightly larger than necessary and would therefore unduly increase the cost of sheltering troops. A provision of 85 square feet would, however, be desirable, and this amount it is quite within the power of the authorities to supply. This, in squad-rooms having an ordinary width of 24 feet, would allow a trifle more than 7 feet of running wall space to each soldier, and would provide an open space of about 4 feet between beds. Certainly such an allowance to the soldier cannot be regarded as extravagant.

As to the minimum amount of air space which should be provided for each man in barracks, there can be no doubt that in most armies an entirely insufficient allowance is made in this respect. In Austria, 540 cubic feet are allowed per capita; in Germany, 540 for cavalry and artillery and 450 for infantry. Laveran states that in the Belgian army the allowance varies from 350 to 420 cubic feet for infantry, with 490 for cavalry; but some barracks recently constructed in that service provide for 600 cubic

feet of space per man. In the British army on the home stations, the amount to which each man is entitled was long since fixed at 600 cubic feet. In our own army it was prescribed in 1870 that north of the 36th parallel there should be a per capita allowance of 600 cubic feet, and south of that parallel of 770 cubic feet. In a report on the condition of our barracks and hospitals made in the year mentioned, it was shown that out of a total of one hundred and forty-one garrisons only thirty-nine were provided with as much as 600 cubic feet of space per man, while in seven stations the cubic space available was as low as 250 cubic feet. At the present time, chiefly as the result of the enlargement of the company organization, a number of our older barracks—originally intended for occupancy by the smaller organizations of former times—afford by no means sufficient air space. The barracks now being constructed, however, provide for an allowance of 660 to 720 cubic feet of space in squad-rooms for each expected occupant. This amount, if it can always be secured, is a great improvement over the allowances for foreign armies; but it must be remembered that the vast standing forces maintained by other nations render it necessary to economize in every possible manner with respect to their maintenance, and such countries as Italy, France, Germany or even England are financially unable fully to provide such accommodations as are well recognized to be to the best advantage of the soldier. In this country, with a small army and a large and wealthy population, no such economic considerations should prevail; and it should not be assumed, because our later barracks are already more spacious than those of relatively impoverished nations, that no further improvement is desirable in this respect. From what has been said establishing the floor space at about 85 feet per man, and the height of the room at $11\frac{1}{2}$ to 12 feet, it follows that the amount of cubic air space which should be available is, in round numbers, 1,000 cubic feet. This amount closely agrees with theoretical standards. It has been stated that the excretion of carbon dioxide by the soldier under the conditions obtaining in barracks is generally regarded as about 0.72 cubic foot per hour, and it is elsewhere shown that the amount of fresh air necessary to dilute this down to the permissible limit of respiratory impurity is 3,600 cubic feet per hour. Experience proves that air in barracks cannot be changed, without special and expensive mechanical means of securing ventilation, much more frequently than three to three and one-half times hourly without drafts being produced. With an allowance of 1,000 cubic feet of air space, to each soldier, all these conditions are properly satisfied with almost mathematical exactness.

For the proper dilution of emanations from the sick in hospital, a much greater amount of fresh air should be supplied than is necessary for soldiers in barracks; and the cubic space per capita must be proportionately enlarged to ensure its distribution without drafts, to the influence of which the sick are especially susceptible. In the German army, 1,300 cubic feet are required to be provided for each patient in hospital. Regulations for the British army allow 1,200; those for the French army 1,400. In our own service no standard is established as to the amount of cubic space to be provided under the same circumstances. It is generally accepted by military sanitarians that, in hospitals, a minimum of 4,000 cubic feet of fresh air per patient should be supplied hourly. If the change

of air is to be three times per hour and the best rate of the entering air currents be calculated at three feet per second, the cubic space should be at least 1,300 cubic feet. Considering, however, the immense benefit to patients of pure air, and the abundant practical experience of medical officers on this point, it is very desirable not to fix the floor and cubic space of hospital wards at the bare minimum of what may suffice; and hence Notter and Firth justly advise that a cubic space of 1,500 to 2,000 cubic feet per capita should be provided for hospital wards. The minimum floor space, in hospitals as in barracks, should be not less than one-twelfth of the cubic space, which gives a minimum allowance of about 110 square feet for each patient in hospital—this being increased where possible to 150–160 square feet. Where means of illumination other than electric incandescent lights are employed, extra air space should be allowed for each burner in barracks and hospitals, unless special means for the removal of impurities resulting from combustion are provided. In foreign armies a larger cubic space is usually provided for the cavalryman than for the foot soldier, for the better dissipation of stable odors.

In single habitations, such as officers' quarters, well furnished with chimneys and sheltering but few occupants under the same roof, the question of cubic air space is of little importance, since the cubic space available is usually in considerable excess of the minimum provided for barracks.

In determining the amount of cubic space in a room the method is simple if the room be square or oblong and has a flat ceiling. In such cases the three dimensions of length, breadth and height are multiplied together. If the room be of irregular form, other measures must be employed. If rectilinear, such places can be divided up into triangles and then measured; or if bounded by curved lines they can be divided up into segments of circles. It is more convenient to make the measurements in meters, or in feet and decimals of a foot, than in feet and inches. For the calculation of superficial and cubic space the following formulæ may be employed:

RULES FOR SUPERFICIAL MEASUREMENT.

Area of circle	= 3.1416 × square of radius.
Area of circle	= 0.0796 × square of circumference.
Circumference of circle	= 3.1416 × diameter.
Diameter of circle	= 0.3183 × circumference.
Area of ellipse	= 3.1416 × ½ long diameter × ½ short diameter.
Area of square or rectangle	= multiply together two sides perpendicular to each other.
Area of triangle	= base × ½ height.
Area of any rectilineal figure	= the sum of the areas of the component triangles.
Area of segment of circle	= ⅔ × chord × height.

RULES FOR CUBICAL MEASUREMENT.

Cube or solid rectangle	= length × breadth × height.
Solid triangle	= section area of triangle × height.
Cylinder	= area of base × height.
Cone or pyramid	= area of base × ⅓ height.
Dome	= area of base × ⅔ height.
Sphere	= diameter cubed × .5236.

To the cubic space of the room, all recesses, such as doorways and window recesses, must be added in. All projections, as chimneys, air-

shafts or fixed lockers, should be deducted, and the cubic space occupied by the bodies of soldiers, generally estimated as about 3 cubic feet per man, must also be subtracted. The amount of air space taken up by furniture, lockers and bedding should, in addition, be taken into consideration, since the free space thus lost for purposes of ventilation is not small. In general, 4 cubic feet may be deducted for each bed with its accompanying bedding, and 4.6 cubic feet for each movable locker of regulation pattern. The total deduction to be made in the case of each soldier in a squad-room thus amounts to about 12 cubic feet.

It has long been recognized that insufficiency of floor and air space in barracks is a potent factor in the occurrence of disease among soldiers, especially with respect to affections of a transmissible nature. Sore throat, headache and malaise are particularly induced by overcrowding and the deficient ventilation thus implied. In the investigation into the sanitary condition of the British army, in 1856, it was found that those regiments provided with the least spacious barracks invariably presented the highest death rates; and since that time an abundance of evidence to the same effect has been accumulated. As an instance in our own service it may be mentioned that, in 1896, it was shown by Owen, at Ford Bayard, that for every case of disease—chiefly of tonsillitis and febricula—which occurred among organizations having a per capita allowance of 730 cubic feet of air space, there occurred 2.5 cases among organizations which had but 420 cubic feet per man.

But in spite of the fact that the dangers of overcrowding are fairly well understood by line officers, it is none the less true that serious overcrowding has occurred within the past few years at a number of posts. From the several recruiting depots such conditions have been frequently reported. At Fort Yates, in 1895, one barrack was stated to have been so crowded that, to get to bed, certain men were obliged to clamber over the foot rails of their bunks or crawl over beds belonging to other men. From Fort Sill, during the same year, an almost identical condition of affairs was reported. In 1892, at St. Francis Barracks, nearly within the tropics, it was reported that the bunks in the squad-rooms were almost touching each other and only 300 cubic feet of air space were available per man. Guard houses especially, during the past ten years, have been reported as overcrowded; and in 1894, at Fort Wingate, in a hot climate, the air space available for each inmate was stated to have been but 217 cubic feet. Many other instances of overcrowding, in lesser degree, have been reported during the past few years; these being apparently due not so much to ignorance as to disregard of the first principles of hygiene on the part of the executive authorities. While much may be excused during time of war, when military necessity may at times temporarily overrule certain sanitary requirements, there is absolutely no justification for the overcrowding of barracks in time of peace. If the proper capacity of the buildings at a post is exceeded, it becomes the plain duty of the sanitary officer to recommend that a sufficient number of men be sent to other stations, so as to allow those left behind the floor and air space to which they are justly entitled. This attitude should be vigorously persisted in despite the opposition which may be excited on the part of line officers, who, from personal motives, are unwilling to see their commands reduced in numbers.

It is certainly unfortunate that our regulations do not explicitly provide for a minimum floor and air space for the soldier in barracks. In the British army, at home stations, each soldier is officially entitled to a minimum of 600 cubic feet of air space, and the door of each squad-room is plainly marked with the floor space and cubic air space of the room, together with the maximum number of occupants authorized under regulations. It would be of great sanitary advantage if a similar custom were established in our own service, and thus do away with the too frequent practice of crowding one hundred men into quarters perhaps originally intended to shelter but seventy-five. Even where the floor and air space is theoretically ample, it should not be forgotten that their value may be largely destroyed by defective facilities for ventilation.

Amount of Fresh Air Required.—The quantity of air required for the ventilation of any confined space will naturally depend upon the nature and amount of the air impurities requiring dilution and removal; these impurities, for all practical purposes, being created by respiration and artificial lights. Of these various impurities, no matter whether from respiration or illumination, the carbon dioxide is accepted as the chief measure of air vitiation; not because the carbon dioxide exists in such amount as at once seriously to influence health, but because it appears to be present in a constant ratio with other offensive and dangerous impurities. As its quantity is very readily determined with sufficient accuracy for all practical purposes, it is therefore taken as the amount of the other impurities in general, and it becomes important to establish a limit of permissible impurity in this respect. This is fixed by Roth and Lex, de Chaumont and others, as already stated, at 0.6 parts per 1,000, which includes 0.4 of initial atmospheric carbon dioxide; they also placing the hourly elimination of carbon dioxide for men of the military class, under ordinary conditions, at 0.72 of a cubic foot. The amount of fresh air necessary to exactly dilute this quantity of carbon dioxide down to permissible limits is 3,600 feet per hour, or one cubic foot per second. Where only 600 cubic feet of air space is provided per man, it is obvious that the air should be changed six times per hour to ensure a proper degree of purity. In practice, however, as already stated, it has been shown that for temperate climates the air of a room cannot usually be changed by common means of ventilation much more than half as frequently without the creation of unpleasant drafts. Hence, for barracks which provide a per capita air space of much less than the standard of 1,000 cubic feet already proposed, it is plain that the supply of the desirable amount of fresh air will rarely be accomplished, except with special mechanical apparatus and at considerable expense—the latter being usually greater than the military establishment can afford to bear. This latter objection was fully recognized by the British commission on barracks, which finally decided, on this account alone, to recommend that as a minimum each soldier in squad-room, having 600 cubic feet of space per capita, should be provided with 1,200 cubic feet of fresh air per hour; though the commission at the same time distinctly stated that this amount was quite insufficient for the dissipation of odors at all times and seasons. The economical objections to supplying an amount of air known to be desirable are also recognized in the Massachusetts school laws, which require a minimum

hourly delivery of 1,800 cubic feet of fresh air per capita, this being less than the amount theoretically required even for children. In our own service it is only attempted to renew the air twice hourly, which with a cubic space of 720 cubic feet in our new barracks means 1,440 cubic feet of fresh air per hour, or less than half what should be supplied. By starting with a proper cubic space, however, these practical difficulties in the way of an economical supply of sufficient fresh air are avoided; and there is no reason why, in squad-rooms of sufficient capacity for the number of men they contain, the air should be vitiated beyond the limits of permissible impurity even with simple means of ventilation. It is true that the practical limit of purity which can be reached in the air of barracks, even if the cubic space be small, depends upon the sum which the government will expend for its attainment; but, as already stated, cost cannot be wholly disregarded, and it is probably ultimately cheaper, and certainly more satisfactory from the military if not the sanitary standpoint, to provide sufficient air space at the outset and accomplish the necessary change of air by other than mechanical contrivances.

Since for soldiers in barracks 0.72 cubic foot of carbon dioxide may be regarded as the average hourly output per capita, and the amount of fresh air required per hour to dilute this carbon dioxide to permissible limits is 3,600 cubic feet, the following table shows the amount of fresh air necessary, under different conditions of cubic space, to dilute the carbon dioxide of respiration to the standard of total permissible impurity of 0.6 per 1,000 volumes of air, inclusive of the amount—0.4—originally present in the air.

Amount of cubic space for one soldier, in cubic feet.	Ratio per 1000 of CO_2 from respiration at the end of one hour, if there has been no change of air.	Amount of air necessary to dilute to respiratory standard of 0.6 during the first hour.	Amount necessary to dilute to the given standard every hour after the first.
100	7.20	3,500	3,600
200	3.60	3,400	3,600
300	2.40	3,300	3,600
400	1.80	3,200	3,600
500	1.44	3,100	3,600
600	1.20	3,000	3,600
700	1.02	2,900	3,600
800	.90	2,800	3,600
900	.80	2,700	3,600
1,000	.72	2,600	3,600

This table of course refers to apartments which, like squad-rooms, are occupied a number of hours consecutively. It is readily apparent that while the air of even the largest rooms ultimately becomes unfit for respiration unless it be properly renewed by ventilation, the larger the air space the less is the necessity for the frequent renewal of air and hence the less the chances of draft. Thus if a space of 100 cubic feet be allowed the soldier, it must have its air changed 36 times in an hour, if the proper amount of 3,600 cubic feet of air are to be given; while the space of 1,000 cubic feet need only have it changed three and one-half times in an hour to secure equal ventilation.

In considering places in which the occupants are actively employed, as drill halls or gymnasia, the amount of air to be supplied must be pro-

portionately increased. In light work, according to Notter and Firth, the carbon dioxide eliminated per hour is nearly 0.006 of a cubic foot per pound of body weight, and in hard work more than double that amount. Thus for the soldier, at the average weight for our service of 145 pounds, there is hourly eliminated 0.86 cubic foot of carbon dioxide during light work, which would properly imply a delivery of 4,140 cubic feet of fresh air during the same period.

For healthy persons, the number of cubic feet of air required per hour may be found by dividing the amount of carbon dioxide exhaled during the same period by the permissible limit of respiratory impurity; and this standard is now generally accepted by sanitarians.

It is conveniently expressed by the following formula: $\frac{E}{P} = D$ where E = the amount of CO_2 exhaled by one individual in an hour, P = the limit of admissible impurity above the amount of CO_2 normally present in the atmosphere, stated per cubic foot, and D = the required delivery of fresh air in cubic feet per hour.

With respect to the amount of fresh air per capita to be delivered hourly in hospitals, experiments seem to show that the amount required as a minimum by the sick is at least one-fourth greater than in health. For military hospitals at least 4,000 cubic feet, in round numbers, should therefore be demanded. In dealing with infectious cases a much greater amount of fresh air must be hourly provided, reaching 5,000, 6,000 or an even greater number of cubic feet if possible—in fact, with such cases the supply should be practically unlimited.

Natural Ventilation.—A room is said to be naturally ventilated when no special measures are taken to ensure the entrance and removal of air, but reliance is had upon perflation through open doors and windows, leakage through their cracks, the percolation of a certain amount of air through walls, and on the aid of chimneys which serve for heating and have not been specially arranged to assist the changing of air. All these methods depend upon certain physical processes which are also made use of in artificial ventilation, and it is thus difficult to define exactly where natural ventilation ends and artificial ventilation begins. Though natural ventilation is usually sufficient for the proper renewal of air in officers' quarters, it is quite inadequate, by itself, in the case of barracks; but when combined with such power as can be got from ordinary sources of warming and lighting, together with special arrangements for securing the maximum assistance from outside air currents, natural ventilation will be of great value in securing the desired results.

The amount of air which percolates through a barrack wall is often considerable, though unfortunately so many factors influence its passage as to make it an uncertain source of supply. Among these factors, pressure of the external air, as seen in winds blowing against the exposed side of a building, is of great importance, and in the absence of such wind a relatively smaller percolation of air takes place. The thickness of walls and the material of which they are constructed also exert a powerful influence. Many observers have investigated the porosity of building materials by determining the amount of air, under varying pressures, which would pass through a given superficies and thickness of the material in a given time, and all are agreed that walls of the usual materials may at

times allow considerable air to pass through them—this insensible percolation often contributing largely to ventilation. Pettenkofer found that the passage of air through the walls of an ordinary dwelling-house, under certain conditions of wind and temperature, was sufficient to change the air of a room of 2,650 cubic feet capacity once every hour. Permeability to air, however, varies greatly with the nature of the building material used. Marble, stone and wood are not very permeable, and cement is less so. Plaster is quite porous, and dry bricks let air pass readily. By covering a brick with wax, save for a small space at either end, and attaching a glass funnel thereto, Pettenkofer was able to blow out a candle flame through the full length of the brick. Moisture, however, practically renders a wall impervious to air, and during rainy weather the passage of air into buildings, through their walls, ceases almost completely. Lathing and plastering somewhat diminish the passage of air, while papering or painting with oil paints almost completely prevent it. For these reasons, the porosity of walls cannot be constantly depended upon as a means of ventilation and should in practice be disregarded in making arrangements for the renewal of air in barracks.

Analogous in its results to the entrance of fresh air through walls and crevices, is the escape from the room, into the atmosphere at large, of gaseous impurities. This is accomplished by diffusion, the rate of which is inversely as the square root of the density of the gas. Pettenkofer and Roscoe showed that diffusion readily took place through brick and stone, though moisture greatly interfered with the rapidity of the process. Through chinks and openings resulting from imperfect carpentry, gaseous impurities diffuse fast. Roscoe found that on evolving carbon dioxide in a room the proportion of this gas in the air was reduced as much as one-half in one and one-half hours. Gréhant, after sealing up the cracks of a room with paper, passed in carbon dioxide until there were 35.7 parts of the latter per 1,000. In twenty-four hours this amount of carbon dioxide was reduced to 0.8 per 1,000. For practical purposes, however, it has been shown that the amount of diffusion in the air of rooms is quite insufficient for its proper purification under ordinary circumstances; and in addition, organic matter, which is molecular and not gaseous, is not affected by it. Hence the purification resulting from the diffusion of gases may be regarded as of only secondary importance in the problem of ventilation and not to be taken into calculation.

Next to the percolation of air into barracks through their walls and the cracks around doors and windows the simplest kind of ventilation, which more properly is aëration, is that through open doors and windows; but this method, except in the warmest weather, causes unpleasant drafts, and for this reason cannot be employed at all times. Nevertheless, when weather permits, advantage should always be taken of it by troops in barracks. It is difficult to appreciate the vast amount of air which is admitted to squad-rooms through opened windows; this quantity being out of all proportion to what can be accomplished even by the best artificial arrangements. Where the outside air is moving at the rate of two miles per hour, a rate which is almost imperceptible, on passing freely through the side windows of a squad-room 24 feet broad it will change the air of that room 440 times per hour. With a moderate breeze the

number of times the air is renewed is greatly increased, and it is obvious that no such powerful ventilating action as is given by perflation can be obtained in any other way. In some foreign armies the great value of perflation is fully recognized, and in the French service it is laid down in regulations that, unless the weather be very inclement, in the morning as soon as the men have arisen and are dressed, all the windows on one side of the squad-room are to be opened; and when the barracks are temporarily vacated, as during drills, they are always to be fully aired. Similar regulations obtain in the British army. In our own service no such ruling is in force, but the windows of the squad-room should be freely opened from reveille until 9 A.M., and again for an hour about evening, regardless of any but extremely stormy weather. The times chosen should preferably be when the greatest number of men are absent on drill or other duty. If the climate and weather be suitable, several or all of the windows of the leeward side of the squad-room should be constantly kept open. Day-rooms are provided in nearly all our barracks, and to these the men may resort without inconvenience during the period of airing. These precautions would seem too obviously necessary to require formal instruction, but experience shows that without constant oversight even the simplest sanitary rules will be disregarded by soldiers.

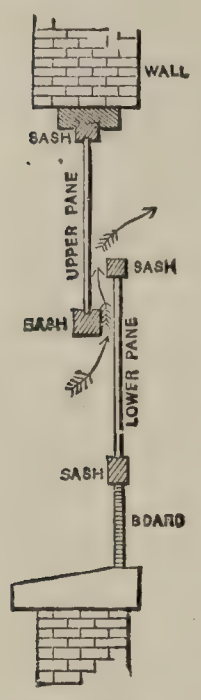
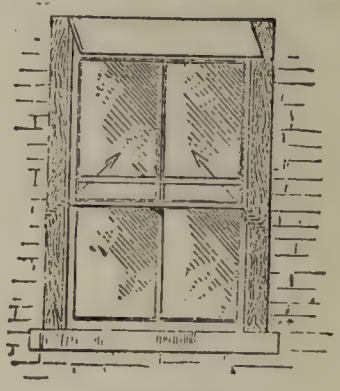


FIG. 212.

Since windows play such an important part in natural ventilation, it is desirable that they be large and extend nearly to the ceiling to prevent stagnation of the upper layers of the air. To ensure thorough lateral ventilation by perflation it is important that, in their location, windows should be directly opposed to each other. The upper sash should also be freely movable. A number of slight modifications of window sashes, in form or arrangement, have been proposed with the idea of admitting a limited supply of air in such a way as to prevent the creation of drafts; and some of these, from their simplicity and efficiency, are of much value for the military service. The best and simplest device for the admission of cold air consists merely in raising the lower sash by an accurately fitting strip of wood, six or eight inches high and sometimes perforated horizontally with small holes. By this arrangement a space is left between the lower and upper sashes through which the air passes in a thin sheet and, being directed upward, curves into the room without perceptible draft (Fig. 212). During cold weather the window can of course be readily closed. A similar arrangement consists in protecting the top of the upper sash by a sloping board. On lowering the upper sash two openings are thus created, the one between the two sashes often serving for the ingress of air while the opening at the top of the window serves as an outlet (Fig. 213). With the same idea, others have proposed to fit window sashes with double panes of glass, an open space being left at the bottom of the outer and the top of the inner panes. This arrangement was tried in the French army, and was found to be unsatisfactory by reason of the fact that the amount


FIG. 213.

of fresh air entering could not be controlled in cold weather, and also because dust rapidly settled between the two panes of glass and could not readily be removed. Double windows, in winter, may be used in the same manner—the swinging panes in the lower outside sash being opened and the upper inside sash being slightly lowered. It has been advised to put perforated plates of heavy glass in the upper part of windows; the perforations being conical and having the larger ends toward the interior, to cause the entering air currents to diminish in force. These apertures are supposed to be closed, as required, by a hinged or sliding plate of glass. Perforated sashes have also been made by boring holes in the lower part of the upper sash. Such a procedure weakens the frame and, like the preceding arrangement, is not desirable for military use. In some French barracks, simple openings made in the lower sash bar, guarded on the inside by a metal plate fixed parallel to the window frame so as to divert the air upward, have been tried. They possess no special advantages. Slats of glass, zinc or iron, constructed on the venetian blind principle, have been recommended to be inserted in window frames. They are mentioned merely because they have been used in some foreign services. Swinging glass sashes are used in a number of foreign barracks for the upper half of the window. These should turn on horizontal rather than vertical pivots to avoid drafts. Sometimes these swing, as in some German barracks, from the lower border; most of the entering air being thus directed upward. Swinging sashes of this character would undoubtedly be valuable for some of our southern posts in this country.

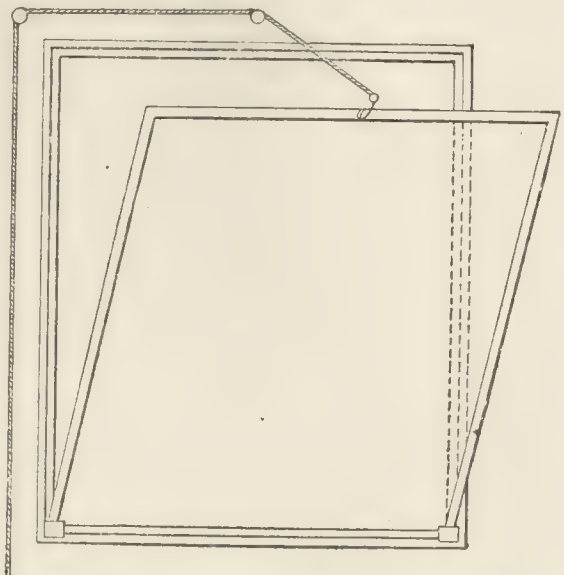


FIG. 214.—Swinging Window Sash.

During the day-time doors serve as a certain means of ventilation; but at night, when all the men are present and vitiation of the air is greatest, they are usually closed. Squad-rooms are often supposed to be partially ventilated through doors opening into halls; but the air in the latter may be impure and the means provided for its renewal be insufficient, as at Washington Barracks, and may be of worse character than that of the rooms it is intended to benefit. This is particularly the case in barracks with dark longitudinal central hallways, of which fortunately but few exist in our service. On the other hand, where the hall is central, transverse, well-lighted and properly ventilated, it serves, together with the stairways running from basement to roof, as an efficient aspirating shaft, in the direction of which there is a general tendency of the air throughout the building to move. Especially in cold weather this movement is quite decided, and it is generally best to make use of it. Under such conditions, transoms should be placed over doors leading into the hall to give exit to air currents.

Location and Size of Ventilating Openings.—The best position of inlets for fresh air is not the same under all circumstances. Practically their location should vary with season, mode of warming, size and shape of rooms, and forces for distributing air. They should not be too large in-

dividually—since any system that does not allow the gradual entrance of air is bad—and should be distributed around the squad-room. If placed too near outlets, the entering fresh air may at once escape without mixing with that throughout the room, since air always moves on the line of least resistance. Theoretically, the proper place of inlets is at the floor of the room; but if they are so located in cold climates the entering air must be warmed; for soldiers will not tolerate chilling of the feet by cold drafts, and inlets offending in this respect are certain to be closed. Entering air may be warmed by being admitted under stoves surrounded by a metal hood, or through boxes containing hot water or steam pipes. In our new barracks the steam radiators are located under the windows and directly in front of the fresh air intakes. The entering air is diverted upward along the flutings of the radiators, is warmed and also continues its vertical direction for some feet after leaving the radiator (Fig. 216). Provision is also made so that fresh air can be admitted directly without passing through the radiators, if desired. In the British service, fireplaces are much used for the heating of barracks, and a part of the entering air is warmed by being passed through ventilating flues in the chimney. This method is unsatisfactory in such severe winter weather as may be expected in the northern parts of this country, although well adapted to moderate degrees of cold. Where inlets are placed in the floors their cleanliness must be carefully looked to, as otherwise they are liable to collect dust, sputum, cigar stubs, match ends and other refuse.

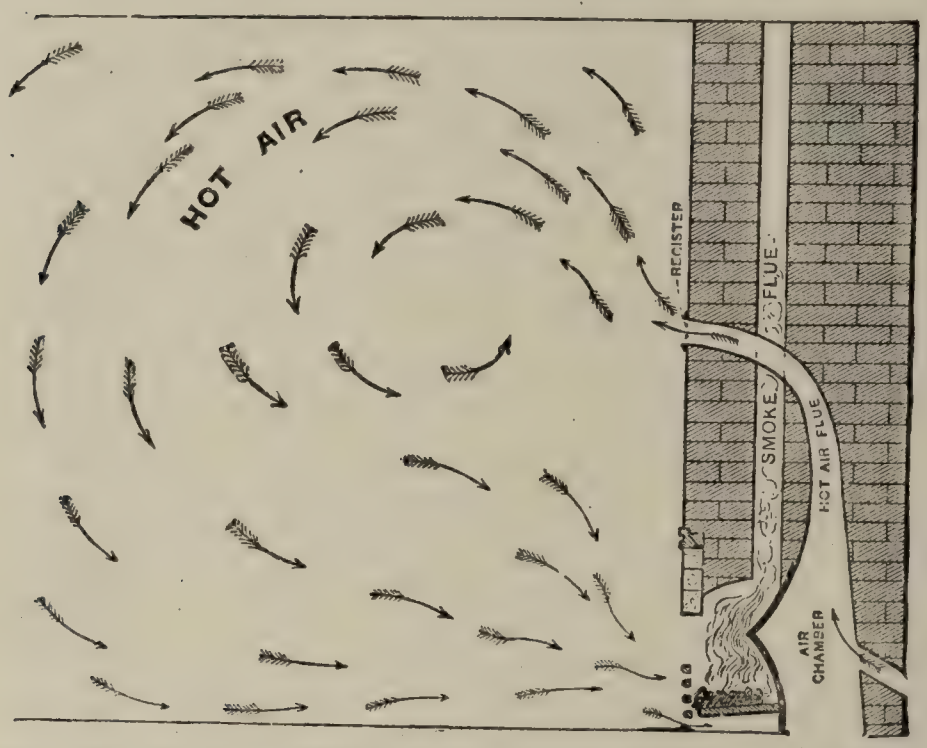


FIG. 215.—Method of Warming and Admitting Fresh Air and Removing Foul Air, as Used in the British Army.

If the entering air cannot be warmed, it should be let into the room at a height of nine or ten feet above the floor, and be directed upward. It thus passes up, is partly warmed by contact with the heated plaster of the ceiling, along which it has a tendency to spread in a thin sheet, and then mixes gradually with the air of the room as it falls. In the British army, half the air brought into barracks is admitted in this way; the other half is warmed before entrance and is admitted at a lower level. In general, for temperate climates, where the air can be heated the entrance should be near the floor. If heating can be accomplished the location of the inlet below is in all respects satisfactory; if it cannot be done, the inlet must be located near the ceiling—theoretical considerations to the contrary. It should be understood that a system which, in practice, works satisfactorily is preferable to one which, though excellent in theory, operates badly.

The location of outlets is a matter of the greatest importance in the ventilation of barracks; and, like that of the inlets, their position should

vary according to circumstances. In general, the positions of inlets and outlets are interdependent. The fact that in heated and occupied rooms the upper layers of air are the most vitiated, points to the theoretical importance of withdrawing the air from a higher level. Moreover at night, which is the period of the greatest vitiation in respect to the air of squad-rooms, the ascent of the respired air and its impurities is rapid, not only from its higher temperature but from the force with which it is propelled upward by recumbent sleepers. On the other hand it has been argued by many that it is better for the foul air to pass off below the level of the person, so that the products of respiration may be immediately drawn down below the mouth and be replaced by descending pure air. But the resistance to be overcome in drawing down the hot air of respiration is so great that there is a considerable waste of power, and the obstacle to the discharge is sometimes sufficient, if the extracting force be at all lessened, to reverse the movement so that fresh air forces its way in through the pipes intended for discharge. It is plain that the location of apertures for the removal of air at points near the floor is opposed by all natural laws governing the movement of air; but nevertheless, where the entering air is unwarmed, this arrangement is probably the best in practice for cold climates. Careful experiments seem definitely to show that the most successful results are obtained, in respect to the mixing of the entering air with that already present, when the inlet is high up in the wall and the outlet is low down diagonally on the opposite side of the room; but to operate such a system the air in the extracting shaft must be warmer than that outside, and the practical efficiency of ventilation will vary with the difference between these temperatures. Usually the heating of the air in the extracting shaft is readily accomplished by some simple arrangement. Often the outlet shafts are built into the chimney and the heat from fires below is thus utilized for ventilation.

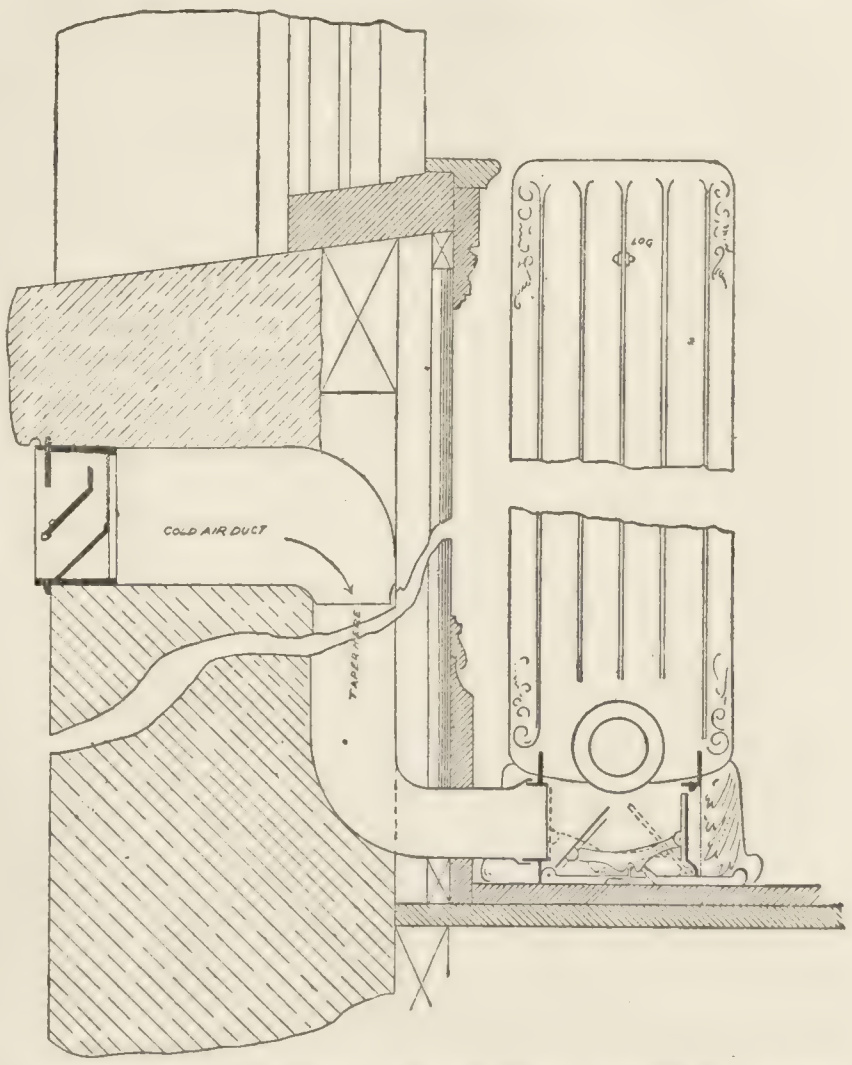


FIG. 216.—Arrangement for the Admission of Warmed Air Into Squad-Rooms. Direct-indirect system.

Where central heating is used, this method is generally employed; though sometimes steam or hot water coils are placed around the base of the shaft for greater heat, as is done in some of our new barracks. With open fireplaces, the chimney itself serves as an excellent extracting shaft. Where ordinary stoves are used for heating, probably the best arrangement consists in running a large air-shaft down

to the floor, preferably in the center of the squad-room, and allowing the stove-pipes to enter this shaft toward the upper part. Openings are then provided at the top and bottom of this shaft—as in fact should be done with all outlet flues—capable of being opened or closed as required; so that in winter the air is drawn out from near the floor level, while in warm weather, when the stoves are not in operation, the upper valve may be opened and the heated air of the apartment thus allowed to escape naturally. This arrangement is partially shown in the accompanying diagram, in which, however, the upper outlet does not appear, since that portion of the air-shaft in which it should be located is cut away to show the arrangement of the stove-pipes. Where a single stove is used for heating, the mistake has at times been made of carrying the pipe directly upward, surrounding it by a flue of larger caliber where it passes out of the room, and in some cases extending this larger pipe nearly down to the stove. Under such conditions, much of the heated entering air at once escapes without mixing with that in the room, to the detriment of not only ventilation but warmth. Where stoves are used, the pipes should be carried horizontally for some distance before entering the outlet shaft and passing upward, so that the points of intake and discharge may be well separated and as much heat as possible be utilized in warming the room.

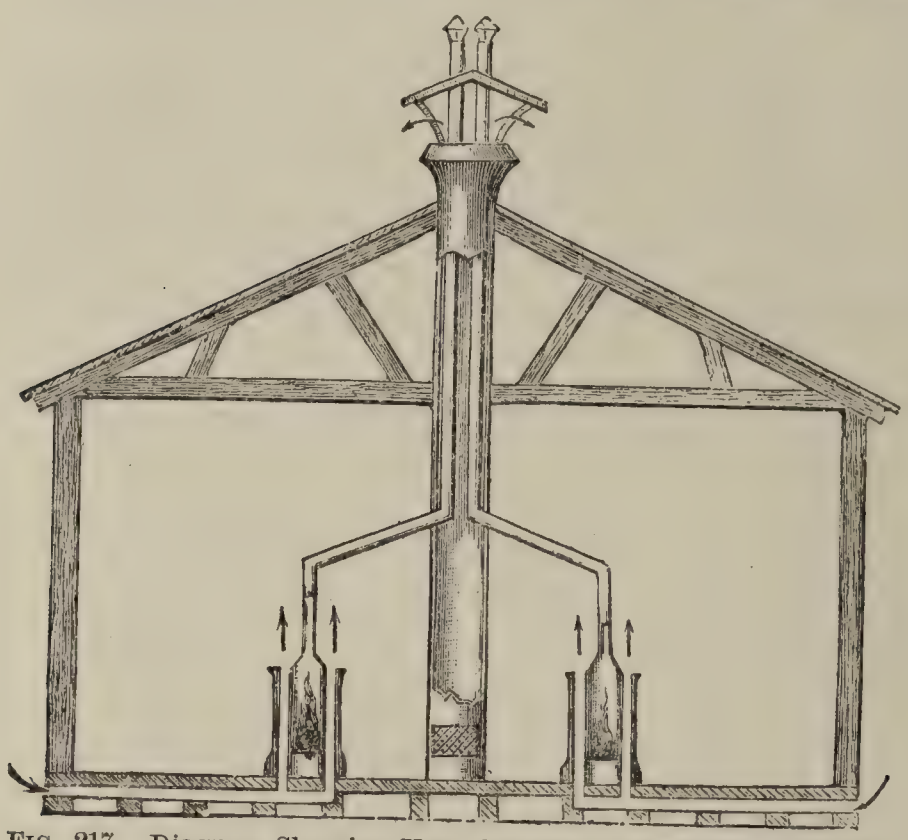


FIG. 217.—Diagram Showing Use of Stoves in Assisting in Ventilation, Together with Location of Inlets and Outlets.

Ir warm climates, or during hot weather when fires are not kept up, the outlets are obviously best located in or close to the ceiling; ridge ventilation probably giving the best results. Of several outlet tubes, under such conditions, the highest outlet is usually the point of greatest discharge, and sometimes the only one—reverse currents perhaps being established through the other shafts. It should not be forgotten that the heat resulting from illumination may be sufficient to change the usual direction of air currents, and thus the problem of renewing the supply of air by day and night may be double, no single arrangement being entirely satisfactory. If possible, ventilating outlets should not be located over beds, since a reversion of air currents, as at times occurs, would create descending drafts of cold air on the men below.

On inquiring as to the minimum size of the ventilating space through which the necessary air has to pass, it is apparent that this entirely depends upon the rapidity with which air can be taken through the space without its movement being perceptible or injurious; this, in its turn,

being secondarily dependent upon the size of the cubic air space provided. The theoretical size for any required change of air, supposing that the conditions are constant, can be obtained by the use of the following formula, suggested by de Chaumont:

$$\frac{D}{200\ f\ (\sqrt{h\ (t - t')} \times 0.002)} = I \text{ or } O.$$

In this formula D = delivery per hour in cubic feet; 200 is a constant; f is the coefficient of friction; h is the height of the heated column of air; t = its temperature; t′ that of the outer air; 0.002 the ratio of expansion of air for each degree F.; I = inlet and O = outlet, both in square inches. It is commonly stated that, as heated air expands, the inlets should be slightly less in area than the outlets. This, however, is so slight that it may safely be disregarded under usual conditions, since with a difference in temperature of 30° F. air expands only one-seventeenth of its volume. Carpenter gives the following figures as showing the ventilating area, in square inches, required for each 1,000 cubic feet of space under different rates of renewal of air.

Velocity in feet per second.	Number of Times Air is Changed Per Hour.					
	1.	2.	3.	4.	5.	6.
1	40. sq. in.	80 sq. in.	120 sq. in.	160 sq. in.	200 sq. in.	240 sq. in.
2	20 "	40 "	60 "	80 "	100 "	120 "
3	13.3 "	26 "	40 "	53 "	67 "	80 "
4	10 "	20 "	30 "	40 "	50 "	60 "
5	8 "	16 "	24 "	34 "	40 "	48 "
6	6.7 "	13 "	20 "	27 "	33 "	40 "

As the movements of air out of and into barracks vary in rapidity according to the difference between internal and external temperatures, it is obviously out of the question to set any one standard of size for ventilating apertures which would be suitable for all conditions; even if the influence of wind be excluded, which is impossible. The only way is to adopt a size which will meet most cases, and also provide means of altering the supply according to circumstances. Sanitarians appear to have generally accepted as standard, for temperate climates, an area per man of twenty-four square inches for inlet and the same for outlet. In the barrack regulations of the British army the sectional area of the ventilating inlet is fixed at twenty-four square inches per capita; but to hourly supply through this space the 3,600 cubic feet of air necessary for the proper dilution of respiratory impurity would imply an entering current having a rapidity of six feet per second, which is too great for comfort. With a three foot rate, only 1,800 cubic feet of fresh air could be supplied hourly through an aperture of this size; and with a rate of this proper character it is clear that theoretical standards, as already discussed, demand a ventilating space of 48 square inches per man. To give the best results each individual inlet opening should not be larger than 48 to 60 square inches, and no outlet should have a sectional area greater than one square foot. With openings of this size located around a squad-room, disagreeable currents are avoided and the general distribution of fresh air is more certain.

Intake Apparatus.—Besides the natural admission of air into barracks through walls, windows and doors, a number of special devices have been proposed to permit of the entrance of a sufficient amount of air without the creation of drafts. While designed primarily for the introduction of air, these arrangements, under varying conditions of wind, temperature and other factors, may also at times serve as outlets.

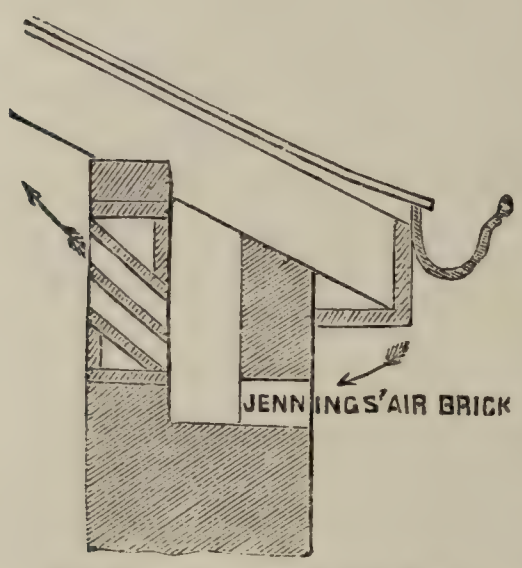


FIG. 218.—Jennings's Air-Brick.

For the admission of air, perforated bricks are sometimes built into walls. These bricks are usually pierced with conical holes of about one-fifth of an inch in diameter, the base pointing internally better to ensure the gradual entrance of air. The usual size of the brick being 3 x 9 inches, the united ventilating area is about $11\frac{1}{2}$ square inches. Another common size is 6 x 10 inches, having an open area of 24 square inches. The air passing in through these holes is so divided that it gives no draft. These bricks are best placed just behind and concealed by the skirting board. Jennings' air-brick is another form of these inlets, being usually placed in the walls near the ceiling. The outside air, before passing into the room, is led into a small chamber where much of its suspended dust is deposited. An open iron frame of the size of a brick, covered with an iron grating and with a valve to close it, is an arrangement for the admission of air which gives fairly good results.

A simple shaft, capped with a swinging cowl so arranged as to always present its open mouth to the direction from which the wind is blowing, affords a ready means for the forcing in of fresh air. These swinging ventilators, however, usually become rusty and hence noisy in their action; beside which they may become jammed or be rusted into a fixed position, in which case they are liable to be converted into aspiratory shafts and serve for the egress instead of the entrance of air. Windsails, as used on board ship, are similar in principle to the above. A fixed cowl for perflation through a downcast shaft is made from a tube, the upper end of which is funnel-shaped and is surmounted by a top shaped like an inverted cone. The wind is thus deflected downward from whatever direction it may come. Both these forms of ventilator may give rise to strong air currents during high winds, while in still and warm days their action may be reversed.


FIG. 219.—Downcast Shaft with Fixed Cowl.

In some cases, ordinary tubes, as proposed by Tobin, provide for the introduction of air from the outside at the floor level and then up a vertical tube inside the room to a point about six feet in height. This gives a vertical direction to the entering current, which is retained for several feet further before it begins to spread and descend. The action of each tube is much affected by the direction of the wind—and like the forms of apparatus just mentioned it may, in fact, be reversed altogether. In some modifications of these tubes the air is

warmed by a gas-jet before entrance. These tubes are liable to get dirty and full of cobwebs, and do not satisfactorily meet the needs of the military service.

One of the best forms of inlet, where unwarmed air is to be admitted, is the Sheringham valve—much used in foreign armies. It consists of a trough having its rear wall removed and pivoted at its lower interior border. Usually it is located about two feet below the ceiling of the room. Air passes in through an opening in the wall behind the trough, and is directed upward by its internal lip. The ventilator can be opened or closed as desired, usually being so balanced as to fall open by its own weight. As used in the British service, the size of the inner opening is 27 square inches. This is somewhat larger than the area of the outside intake, and the velocity of the entering air is proportionately lessened. The wind blows through these valves and the movement of air is therefore variable. They are often outlets; in fact it depends upon circumstances as to whether they act as inlets or outlets. Very little draft is caused by them save in high winds, and they are generally regarded as very satisfactory. Similar to these valves, but not so readily operated, are drawer-shaped inlets having no back wall. These work horizontally back and forth. When pulled out into the room, air passes through them and is deflected upward by the interior border.

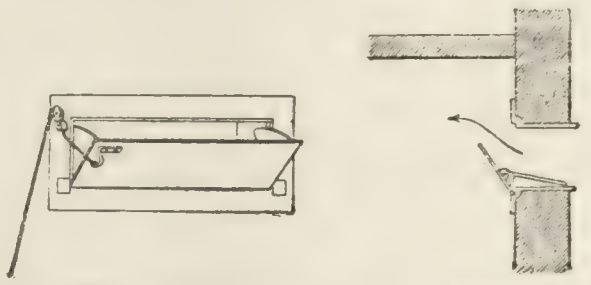


FIG. 220.—Sheringham Valve. Front and sectional view.

The ventilating cornice, used in the British and other foreign services, is especially designed to limit the liability to drafts. In character it does not greatly differ from the Sheringham valve, and, like it, is placed covering an aperture in the wall, a little below the ceiling; being considerably larger than the opening it guards. The top is covered with zinc pierced with numerous small holes, save directly over the aperture in the wall. In this manner entering air currents are completely broken up and the fresh air passes insensibly into the room. The total area of the small holes in the top of the cornice should be six or eight times the size of the orifice of admission. Sometimes a valve is also used with this apparatus.

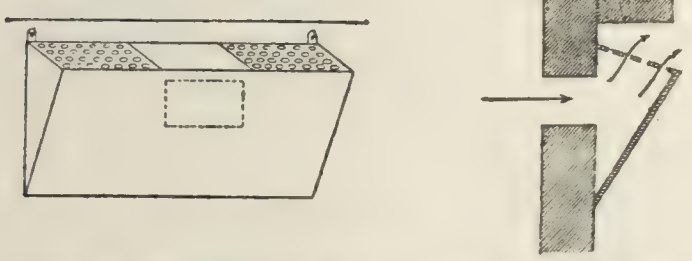


FIG. 221.—Ventilating Cornice. Front and sectional view.

In this connection, it may be stated that all delivering air-shafts should be short and capable of being easily cleansed. This is an important matter, and should lead to the rejection of all plans in which the reverse prevails. With long shafts, friction is great, dirt lodges and the entering air is impure. As already stated, intakes should be numerous and small rather than large or single, and should preferably be enlarged where they enter the room. This is important in preventing drafts. For the same reason their external orifices should be partially protected from the wind, since otherwise the latter may blow through them too rapidly Sometimes the

intake shaft is curved for this purpose, or an overhanging shelf or hood may be used. Means should be taken to divert the air upward on entering the room. Gratings over both ends of the shaft are important to exclude foreign objects, but they should be capable of ready removal for purposes of cleanliness. Since gratings reduce the size of the openings to some extent, an allowance in this respect may have to be made; with ordinary registers, this generally amounts to about 30 per cent. Where wire netting of large mesh is used to protect the opening no special allowance in this respect is required. All intakes should be provided with valves, so that they may be closed if required. They should always open externally at least one foot above the surface of the ground, and the latter should be open, dry and well policed. If possible, the neighboring ground should be covered with short grass to limit the creation of dust. All shafts should be frequently inspected as to their cleanliness and perviousness, and this is especially important in cold weather. Mention has been made of the special tendency on the part of soldiers to stop them up at such times.

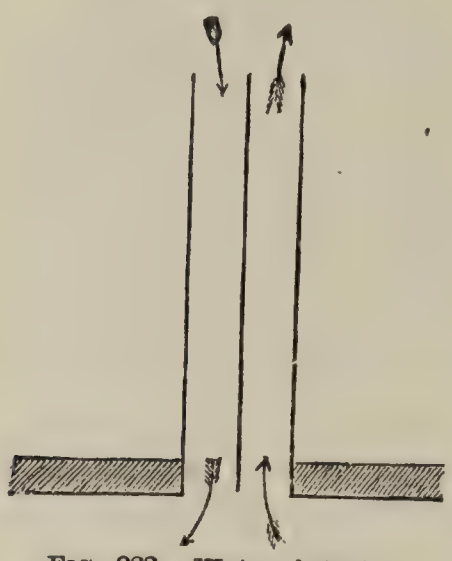


FIG. 222.—Watson's Tube.

Combined Inlets and Outlets.—A number of simple but excellent arrangements for the renewal of air in rooms have been proposed, depending for their action on natural processes. These are usually planned to act at the same time as both inlets and outlets. A single vertical shaft has sometimes been used for this purpose, double currents of air being established through it. This is a crude plan, as there are no means of distributing the air, and the friction of the opposing currents—together with the action of winds and conditions of temperature—is often so great as to stop the movement of air through it. To avoid these inconveniences, Watson suggested the simple plan of merely dividing the air-shaft by a longitudinal partition. With this arrangement, when placed in the ceiling of a room, ascending currents are established by the heated air through one compartment, while cold air flows down through the other compartment to replace what has passed out. In shafts of this character, accidental circumstances, such as the wind, sun's rays or proximity of artificial heat, will determine which channel is outlet and which is inlet. They are so far better than the single tube in that the partition divides the currents and prevents friction, but there is irregularity of action and the distribution of air is not good. The Muir ventilator is similar to that proposed by Watson, consisting merely of a box or shaft divided longitudinally into four compartments by diagonally located partitions. The upper part of the shaft, where it projects above the roof, is protected by slats; these being inclined upward to prevent down-drafts and assist the movement of up-currents by the aspiratory action of the wind. Through the heat of the sun and action of the wind, two compartments of this ventilator serve as outlets, while descending currents are established through the others.

The McKinnell ventilator is a perfected type of the Watson tube. It is composed of two cylinders; one inside the other and separated by an interval having a total area equal to the sectional area of the inner tube.

This interior tube projects beyond the external one at both top and bottom. The inner tube is the outlet tube; this being so because the outer casing of air maintains a higher temperature in it, and it is also made higher than the other and is protected by a cowl above it. As the warm air escapes through the inner tube a corresponding amount of cold air flows in through the interspace between the pipes, and is diverted by the flange on the lower end of the inner pipe toward the walls of the room. A lamp or gas jet swung immediately below this ventilator adds greatly to its efficiency at night. It has been much used in foreign barracks.

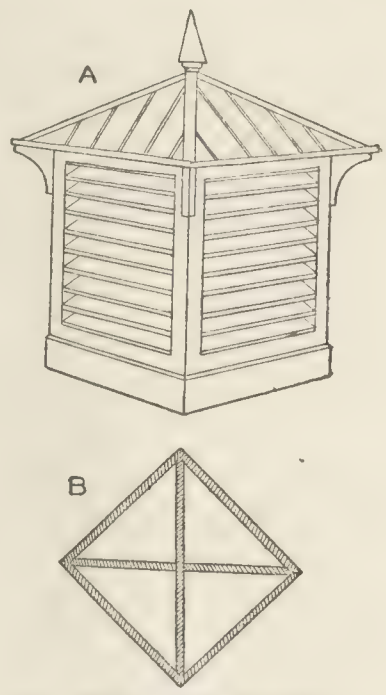
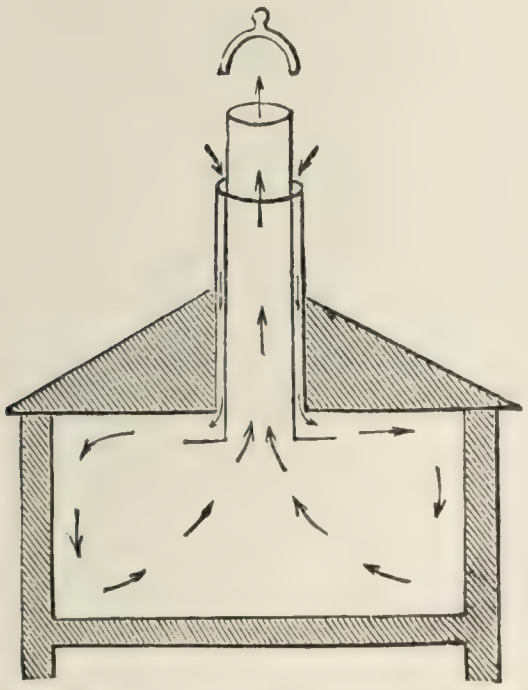


FIG. 223.—Muir Ventilator. *B*, Transverse section of same.

Simple ridge openings may be used in one-story buildings and are generally employed in our older style of post hospitals. During the Civil War especially they were much used. They ventilate most thoroughly, but snow sometimes drifts in. The entrance of rain can be prevented by carrying down the sides of the overhanging ridge for some little distance, and a flange placed a short distance below the opening will throw any down-draft toward the walls. To be of most advantage, the space under the longitudinal ventilating ridge should be continuous throughout with the room below. In many instances in our service, foul air can escape from the room into the ventilator space only through gratings, the latter catching and retaining much dust and being cleansed with the greatest difficulty. In many instances also, where ridge ventilation has been provided, there is an utter lack of proportion between the small gratings in the ceiling and the large apertures in the ventilating ridge. During cold weather ridge ventilators must be closed.

All the forms of ventilators above described serve purely as outlets when the windows and doors of the room are open. If these be closed and open fireplaces or stoves are used, the currents may be reversed and the ventilators thus act as intakes only.


FIG. 224.—McKinnell's Circular Ventilator.

Fairly good ventilation can be secured by means of a series of horizontal ventilating shafts placed close to the ceiling. These, running across the room from wall to wall, open into the air at each end by a ventilating air brick or register. The sides of these tubes are of perforated zinc and, to prevent the wind blowing directly through, the center is divided vertically by a partition. According as the wind blows from one side or another, one part of the shaft becomes an inlet and the other an outlet.

It is obvious that the different arrangements for ventilation described above possess a special value for the military service, since they present no mechanical difficulties of construction and may be satisfactorily improvised in an

emergency out of any materials which may be at hand. Where troops are placed in temporary and roughly constructed winter-quarters, the establishment of simple arrangements of this kind will add greatly to the ventilation and healthfulness of the latter.

Extraction by Heat.—The proper ventilation of barracks is inseparably connected with the heating of air. In becoming warmer, air endeavors to expand, and if there be any opportunity for it to escape a portion of it will do so, and that which remains will be lighter than an equal bulk of the colder air outside. The outer air will then flow into the room by every orifice until the equality of weight outside and inside is re-established. But as the fresh air which comes in is heated in its turn, the movement is kept up in a constant stream, cold air entering by one set of openings and warm air escaping by another.

In winter, the artificial warming of barracks greatly assists the change of air within them, as does also the means used for illumination. The amount of heat given off from the bodies of soldiers is also no small factor in raising the temperature of squad-rooms above that of the open air. Putzeys states that about 67 per cent. of the body heat of an individual is ordinarily lost by radiation and contact, and the same writer quotes figures given by Barral to the effect that the heat given off by the body of an adult is capable of raising the temperature of 500 cubic feet of air 27° F. in an hour. This amount of heat given off by the bodies of soldiers is not only a point to be considered in connection with the necessity for renewing the air in barracks, but may thus become a factor of importance in relation to the processes by which this is accomplished. Obviously it is during winter that ventilators have their maximum influence. In summer or in tropical climates the outside temperature is high, and the influence of heat upon the renewal of air in rooms is reduced to the minimum—but fortunately under these conditions special methods of ventilation depending upon heat are of less importance, since at such times the outside doors and windows are generally kept open.

In calculating the rapidity with which ventilating air currents will pass in and out of heated barracks, use is generally made of two well-known physical laws: First, that the velocity in feet per second of falling bodies is equal to nearly eight times the square root of the height through which they have fallen; and second, that fluids pass through an orifice in a partition with a velocity equal to that which a body would attain in falling through a height equal to the difference in level of the fluid on both sides of the partition. In the consideration of air currents there is substituted for the difference of level the difference in pressure on the two sides of the partition or opening, and this is expressed by the difference in height of the openings of entrance and exit, divided by 491; $\frac{1}{491}$ representing the expansion of the atmosphere in volume and lessening of density for each degree (Fahrenheit) of rise in temperature. The velocity of influx or outgo will, therefore, equal

$$8\sqrt{\frac{(\text{diff. in temp.}) \times (\text{diff. in height})}{491.}}$$

For determining the velocity of the movement of air up a heat extraction shaft, the following formula is offered by Notter and Firth:

$$V = 36.5\sqrt{H\,(t - T)}.$$

In this, V is the velocity in feet per second, H is the height of the shaft in feet, t is the temperature at the top of the shaft, and T is the temperature of the air supplying it. The velocity multiplied by the sectional area of the shaft gives the cubical discharge. In practice an allowance must be made for friction. Billings places this at from twenty to fifty per cent., so minute calculations are useless.

Carpenter gives the following table showing the quantity of air, in cubic feet, discharged per minute through a shaft of which the cross-sectional area is one square foot; the external temperature of air being figured at 32° F., and the allowance for friction being fifty per cent. Under most conditions in the military service the allowance for friction need not be so high, usually not more than twenty-five to thirty-five per cent.

Height of flue in feet.	Elevation of Temperature of Air in Flue Above that of External Air.							
	5°.	10°.	15°.	20°.	25°.	30°.	50°.	100°.
	cubic feet.	cubic feet.	cubic feet.	cubic feet.	cubic feet.	cubic feet.	cubic feet.	cubic feet.
1	24	34	42	48	54	59	76	108
5	55	76	94	109	121	134	167	242
10	77	108	133	153	171	188	242	342
15	94	133	162	188	210	230	297	419
20	108	153	188	217	242	265	342	484
25	121	171	210	242	271	297	383	541
30	133	188	230	265	297	325	419	593
35	143	203	248	286	320	351	453	640
40	153	217	265	306	342	375	484	684
45	162	230	282	325	363	398	514	724
50	171	242	297	342	383	419	541	765
60	188	264	325	373	420	461	594	835

From this table it is apparent that where the foul air of different floors of a barrack building is removed through heat extraction shafts, the discharge of air from the lower rooms, other conditions of size of shafts and temperature being the same, will be much greater than from those of the upper story. It follows also that where a squad-room is ventilated through several up-cast shafts, the length of these, together with their exposure to cooling influences, should be the same. Billings states that the movement of air in outlet shafts is normally about five feet per second from lower floors and four feet per second from upper rooms, provided that the flue is not artificially heated above room temperature. It is clear that to secure an equal outflow of air from upper floors there must be a proportionate increase in the sectional area of their discharge shafts. These are all practical points which appear to have rarely received consideration in our service.

Ordinary chimneys with open fireplaces afford excellent facilities for the extraction of air by heat, the outgoing current of air being proportional to the size of the fire and of the chimney. A small fire is said to give an upward movement of air at the rate of about five feet per second; a large open fire of eight or nine. With open fires, all other openings usually become inlets, the movement of the air in the room being toward the fireplace. In the British and other foreign armies, open fires are much used; in our own service they are rarely employed, since they are wasteful of fuel in proportion to the heat they give out into the room.

Efforts have been made to use the drafts passing up the chimneys, where stoves or furnaces are used, for the aspiration and escape of vitiated air from the room; but with ordinary openings reverse currents, with an influx of smoke and gas into the room, were always to be apprehended. To overcome this fault, valves of some light material, opening only toward the chimney, have been employed. Arnott's valve consists of a light silk curtain which lifts up readily when the movement of air is outward, but is pressed flat against a metal grating by reverse currents and thus closes the opening. With this valve there is sometimes reflux of smoke from the silk curtain not fitting tightly. To overcome this defect, Boyle suggested the use of thin mica plates; and recently plates of aluminum have been employed for the same purpose. It is very evident that such valves will not be lifted by the weaker currents of air, and the snapping noise they make when closing, especially with metal flaps, is said to be sometimes objectionable. On the whole, however, these valves may at times serve a useful purpose as accessory to other means of ventilation.

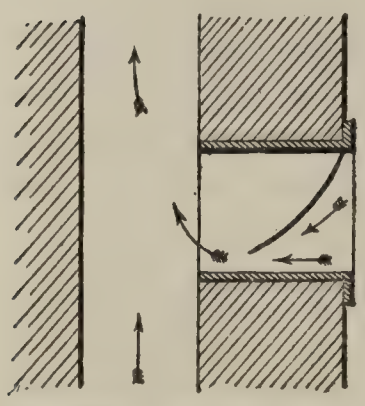


FIG. 225.—Arnott's Valve.

Even when they have no fire in them, chimneys may serve as heat extraction shafts through the heating of the upper part of the chimney by the sun. To aid in this respect, chimneys may with advantage be painted black to better absorb the solar heat; and in some cases the roof immediately around the chimneys, together with screens on the northern exposure, have been painted white with a view of reflecting additional heat rays upon them. These simple measures may of course be taken to increase the efficiency of ordinary up-cast ventilating shafts as well as chimneys. It should not be forgotten, however, that where these shafts project much above the roof, they are also exposed to cooling influences which retard the passage of air up them. Wherever the heat in the rooms below is greater than that of the surrounding air, an ascending current through the chimney will be established; while if the temperature of the air in the chimney be from any cause lower than that of the surrounding air a reverse current is established. While affording valuable assistance in ventilation, chimneys and open fireplaces are not sufficient for the proper renewal of air in large and crowded rooms, as in barracks, and additional measures should be provided where they are used.

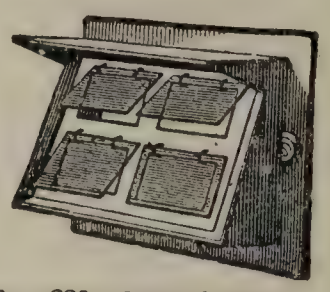


FIG. 226.—Boyle's Valve. Back view.

As previously mentioned, the temperature of extracting shafts is usually maintained at a sufficiently high level, where stoves are employed for warming, by passing the stove pipes up through the shafts before discharging into the chimney or outer air. This utilizes much of the heat which might otherwise be lost. Where steam heat or hot water is used for warming barracks, the pipes may be coiled around the lower part of the ventilating shaft to maintain it at the desired temperature. In some of our new barracks, heated in this manner, this method is not used; it being claimed that sufficiently good results are obtained by building the ventilating up-cast shafts in the masonry of

the chimney, and utilizing such heat as may be conducted through the walls of the latter. This method, though valuable, can obviously be improved upon. All methods of ventilation by extraction by heat are unsatisfactory unless a sufficiently elevated temperature is maintained in the flues; though usually when no fires are kept up the outside temperature is such that recourse can be had to natural renewal of air by open windows and doors. There are occasions, however, when such arrangements are unsatisfactory; and under such conditions lamps or gas-jets may be used to heat the shaft and promote up-currents. The burners should be located at the bottom of the shafts to give the maximum results. The relation between the amount of coal-gas burned and the volume of air removed is variable; Morin having shown that it was much more economical to distribute the heat in a flue with a large sectional area than to burn the same amount of gas in a small shaft. Notter and Firth state that one cubic foot of gas burned is capable of extracting 3,000 cubic feet of air, under favorable conditions; while Laveran places the average amount which can in practice be removed at 2,500 cubic feet. Instead of burning the gas or oil directly in the shaft, the lower part of the latter can be made of sheet metal, the flame being maintained beneath this metal frame, as shown in Fig. 227. As mentioned elsewhere, it is extremely important that the heat resulting from illumination should be utilized for room ventilation, the same means removing the heat and the impurities resulting from combustion. The latter may be collected in a funnel over the lamp or gas-jet, and can be conducted outside by an extracting shaft, together with much of the heated and impure air of the room itself. The Wenham recuperative burner, described in the section on the lighting of barracks, is of excellent service in promoting ventilation.

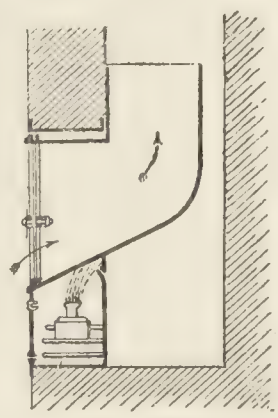


FIG. 227.

Wherever shafts are used for the extraction of air by heat, it is obvious that they should be enclosed within walls as much as possible to prevent the contained air from being cooled. This simple point has sometimes been overlooked, and the efficiency of up-cast shafts thus practically destroyed. Where central heating is employed, the ventilating shafts are best placed between partition walls; since if they are located in outer walls a certain amount of chilling is unavoidable. Where stoves are used in pavilion barracks or wards, the extracting shafts are best placed in the center of the room with respect to the prevention of chilling—though when so placed they are somewhat inconvenient for purposes of administration. Extracting shafts should be as straight as possible and possess smooth interior surfaces, so that friction should be reduced to the minimum. They are best made cylindrical for the same reason; and should be capped with cowls to aid the aspiratory action of the wind, reduce the liability of down-drafts and prevent the entrance of rain, which, by its evaporation, would tend to lower the temperature of the shaft and interfere with its operation. Sometimes, also, the heated air becomes cooled by passage through an exposed tube, as already suggested, so that it cannot overcome the weight of the superimposed atmosphere; or another outlet shaft of greater discharge may reverse the current. This possible reversion of action in outlet tubes is a reason why proper attention should be given to their cleanliness.

Ventilation by Aspiration.—The action of winds is of considerable value in securing the proper renewal of air in barracks. A moving body of air sets in motion all air in its vicinity. It drives air before it and, at the same time, causes a partial vacuum on either side of its own path, toward which all the air in the vicinity flows at angles more or less approaching right angles. In this way a small current moving at a high velocity will set in motion a large body of air. Advantage can be taken of this aspiratory power of the wind to cause a movement of air up an ordinary shaft; the rapidity of the ascending current being in direct relation to the horizontal velocity of the wind. The latter, however, in the absence of proper means of protecting the top of the shaft, may at times impede ventilation by obstructing the exit of air from any particular opening, or by blowing down a chimney or tube. This is, in fact, one reason for the failure of so many of the less carefully planned systems of ventilation; they may work well in a fairly still atmosphere, but the immense resistance of high winds has not been taken into account.

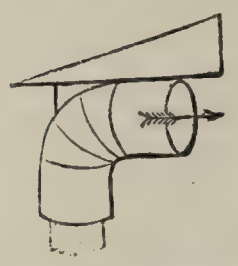


FIG. 228.—Rotating Cowl for Aspiration.

The aspiratory power of the wind and the production of a head for ventilation, by the movement of air over the mouth of a tube, can best be secured by covering the air-shaft with a cowl, which both aids up-currents and prevents down-drafts. This is practically the idea with which all varieties of up-cast ventilators are constructed, however varied may be their external appearance. As usually fixed to buildings, cowls may be uncertain in their action from the variability of the wind currents, due to the effects of the surfaces of the buildings themselves. Although many forms of cowl have been designed to render up-cast ventilators serviceable, irrespective of the direction from which the wind blows, there are practically only two types; namely, those with rotating cowls and those with fixed vanes. Of the former type the simplest form is shown in the accompanying illustration (Fig. 228), it setting itself by means of a wind-vane so that the opening always faces away from the wind. An improvement on this primitive type is Banner's cowl, which probably represents the best form of rotating aspiratory ventilator. In winter, however, this apparatus is said to be liable to be stopped up with snow. In general, all rotating cowls are very efficient so long as they act as intended; but they are apt to become fixed and have their action reversed by winds from the opposite direction. When rusty, their movement is accompanied by an unpleasant grating noise, but on the whole they are satisfactory.

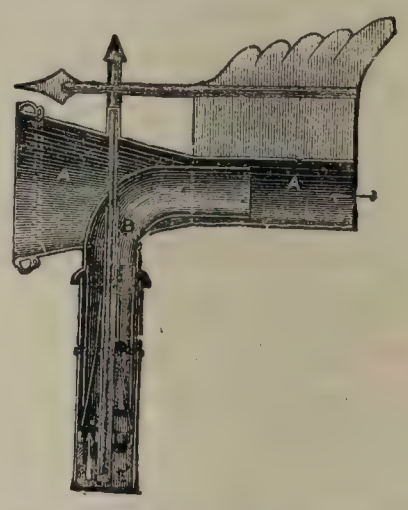


FIG. 229.—Banner's Rotating Exhaust Ventilator.



FIG. 230.—Star Ventilator.

The fixed type of exhaust apparatus is best represented by the Star ventilator, now being used in our service to the exclusion of other models. In it the motion of air is always tangential to the shaft opening, from whatever direction the wind blows. This ventilator is very efficient as regards as-

piration, is protected against rain and down-drafts and does not collect snow and ice in winter. Somewhat similar in principle to this, but less efficient, is the Wolpert ventilator, much used in foreign services. This consists merely of a pipe supporting an aspiratory chamber flaring at the bottom and with a protective cap fastened a couple of inches above its upper margin. Down-drafts are effectually prevented with this apparatus, but its aspiratory effect is by no means as great as is given by the Star ventilator. A third modification of the fixed ventilator is the Hanks apparatus. This is an excellent ventilator having a powerful exhausting effect, the large amount of wind brought to act on the orifice of the inner pipe having great extracting power even in a gentle breeze. A cap to protect against storm-water and minimize down-drafts is generally used with this ventilator. A common modification of an ordinary up-cast shaft, and one which gives fairly good results, consists in adding a simple flange which slopes downward and outward from the rim of the tube. This increases aspiration by giving an upward tendency to horizontal air currents. A conical roof keeps out rain and prevents down-drafts.

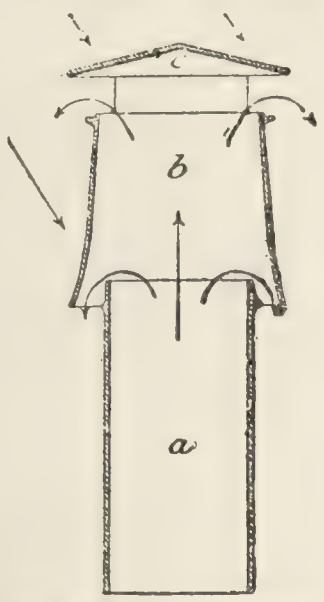
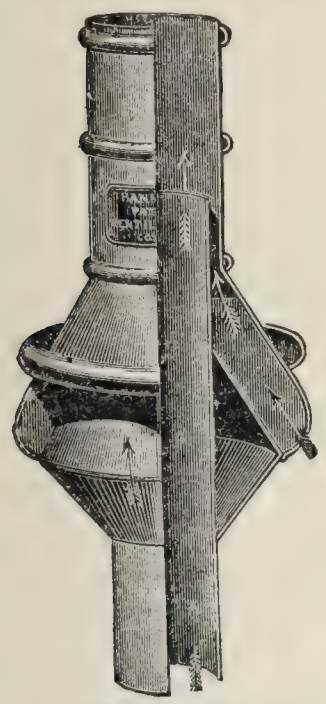


FIG. 231. — Wolpert's Ventilator.


FIG. 232.—Hanks's Ventilator.

From the simple construction of aspirating cowls it is evident that, in an emergency, excellent makeshifts can readily be improvised from a few joints of stove pipe and such sheet metal as can readily be obtained from old coal-oil cans or water buckets. It having been found that where a number of small separate flues lead from a single room they are liable to pull against each other, it will frequently be of advantage to bring several of such flues together to a single outlet, protected by a suitable ventilating cowl.

Other Means of Ventilation.—The renewal of air by means of fans is accomplished by either extraction or propulsion. The latter method is usually preferable, since the entering air may be drawn from a source known to be pure, and may be heated or cooled before being passed into the apartment. By this means fresh air can be distributed with ease and certainty at any rate and in any quantity. The disadvantages are great cost of operation and the constant possibility of breaking down at the time when most required. On account of the expense attached to its operation this method of ventilation is not suited to barracks, though well adapted to hospitals. Several hospitals in the French military service are ventilated in this manner; the movement of the fan, in one case, changing its direction every half hour, forcing air in and drawing it out alternately. The system of ventilation by propulsion has been tried in our service, having been installed at Madison Barracks a num-


FIG. 233. — Tube with Fixed Cowl for Aspiration.

ber of years ago. The results given by it as regards the renewal of air were reported as excellent; but motives of economy later resulted in its disuse, and other methods of ventilation have been substituted for it. Either steam or electricity may be used for power. The chief fans used for this method of ventilation are the Blackman air propeller and the Wing circular fan. The larger sizes of the Blackman fans are said to give 12,000 cubic feet of air per minute, and the smaller sizes 6,000 cubic feet, per horse-power. This estimate is based on the supposition that there is no resistance against the air save from the machine itself. In practice there is much friction, with resulting loss. The Wing disc fan has been much used for building ventilation. A four-foot fan is stated to move 500,000 cubic feet of air per hour, using one horse-power. The best fans for use are those of large size, since with them there is less noise and wear as the result of operation.

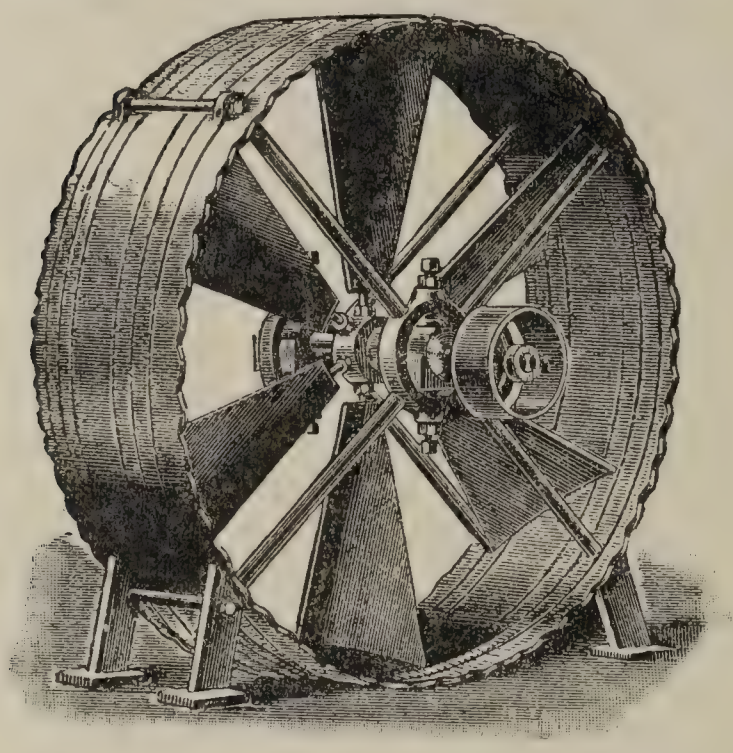


FIG. 234.—Wing Disc Fan.

Steam jets have been used for the production of air currents in discharge ventilating shafts. They are obviously available only where an abundance of steam is at hand, and possess no advantages for the ventilation of barracks. They have been much used on the troop-ships of the British service. Their use is confined to extraction, in which they are very efficient. The cone of steam is said to set in motion a column of air equal to 217 times its own bulk, and some of the larger sizes of apparatus will extract 100,000 cubic feet of air per hour. The principle of the apparatus is very simple, as is shown in the accompanying illustration (Fig. 236).

During the last few years, hydraulic ventilators have been constructed by which, irrespective of atmospheric conditions, the movement of large quantities of air is accomplished by means of water sprayed under high pressure. These hydraulic ventilators are said to be much used in Germany and to be in operation in some of the barracks of that country. For their use an abundant supply of water under considerable pressure is necessary. They are said to be not costly in operation and to be capable of supplying 70,000 cubic feet of air per hour. They consist merely of U-shaped pipes containing spray nozzles. The air is sucked in and passed forward by the falling spray, while the water collects in the bottom and is discharged through a pipe at the lowest point. Being provided with a spray nozzle

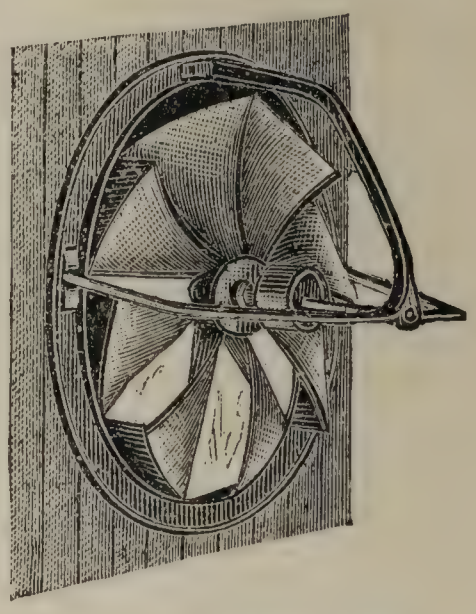


FIG. 235.—Blackman Wheel.

in each shaft, the apparatus is capable of ventilating either by propulsion or aspiration. Certain forms are made for hospitals which, in warm weather, may be readily disconnected with the outside air and the air in the room passed through them, thus materially lowering its temperature. The apparatus clearly cannot be used in cold weather and its proper operation is said to be interfered with by the use of muddy water. It has little value for the military service.

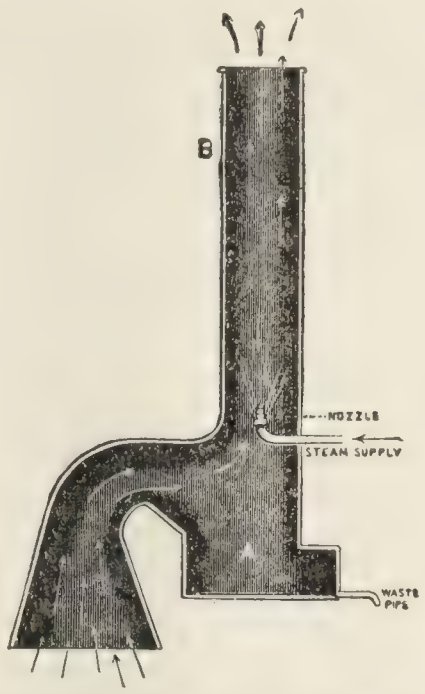


FIG. 236.—Steam-Jet Ventilator.

Examination of Ventilation.—Since the sanitary officer may be required to report upon the sufficiency of an existing system of ventilation, it is important to consider briefly the best means for arriving at conclusions in this respect.

In an occupied room, a determination of the proportion of carbon dioxide present is chiefly relied upon in deciding as to the efficiency of ventilation. The results given by this method, as subsequently detailed, are conclusive. Where a room is not occupied, the most reliable means for determining the sufficiency of ventilation is based upon the fact that if in a closed room there be generated any easily recognizable gas, as carbon dioxide, the amount of fresh air entering in a given time may be determined from the dilution experienced by the gas during this time, not only by the exchange of air through the ventilators but also through cracks and crevices. For the generation of the carbon dioxide, Pettenkofer recommends the burning of stearine candles of good quality; such candles giving off about 2.764 grams, or 1.404 liters, of CO_2 per gram of stearine burned. After the combustion of a number of these candles in the room, with its ventilators and doors closed, a chemical analysis of the air, taken from the centre of the room by a rubber pipe, is made. The ventilators are then opened, and two determinations of the carbon dioxide made at intervals of thirty minutes.

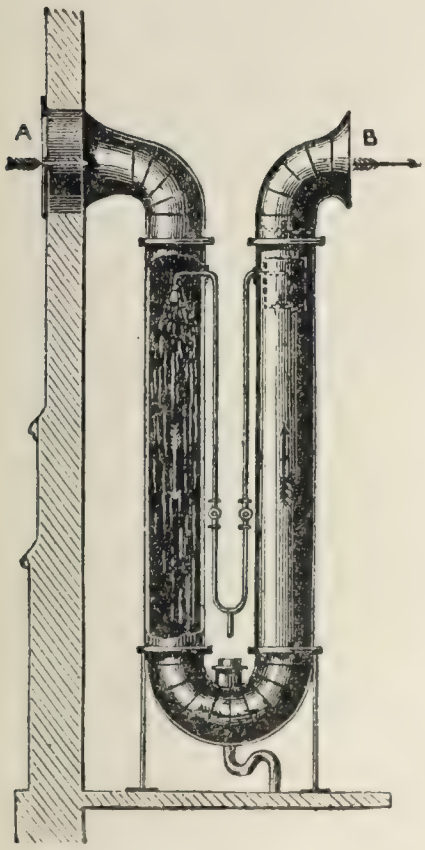


FIG. 237.—Water-Spray Ventilator.

Since in the military service the chemical analysis of air may not always be practicable, recourse may be had to the sense of smell, which, under such conditions, will furnish a useful and ready means of estimating the sufficiency of ventilation; since it has been shown that the amounts of mal-odorous organic respiratory impurities and of carbon dioxide present have, within certain limits, a definite relation to each other. The results obtained are of course not exact and vary to some extent with the observer, but they are sufficiently accurate to be of much practical value. The test is best carried out in barracks at the period of greatest respiratory impurity, or shortly before reveille. The air-space should be entered directly from the external

air, or as near so as possible, since the sense of smell is rapidly impaired in vitiated air. In a large number of tests made by de Chaumont to determine the value of this process, the amount of carbon dioxide was found by chemical analysis at the same time, so that the existing respiratory impurity was accurately known. On dividing his observations into groups, the following results were obtained:

	Fresh, or not differing sensibly from the outer air.	Rather close; organic matter becoming perceptible.	Close; organic matter disagreeable.	Very close, organic matter offensive and oppressive; limit of differentiation by the sense of smell.
Mean CO_2 per 1,000 vols., reduced to 32° F., due to respiratory impurity alone.	0.1943	0.4132	0.6708	0.9054

From this it is apparent that the odor of organic matter is, on an average, imperceptible to the sense of smell when the coincident CO_2, due to respiratory impurity, does not exceed 0.1943 per 1,000; and that when it reaches 0.9054, the olfactories are no longer able to detect grades of difference. In round numbers, 0.2 per 1,000 may therefore be taken as the maximum amount of respiratory impurity as regards carbon dioxide—or 0.6 per 1,000 when added to the carbon dioxide normally present in the air—admissible in a properly ventilated space. This relation between air vitiation and the odor to which it gives rise in an occupied room varies to some extent with the temperature and the amount of moisture present; under some circumstances the odor due to organic contamination from respiration may not be perceptible until the carbon dioxide exceeds 0.3 parts per thousand. By bearing the above figures in mind an approximation of the amount of respiratory impurity in a squad-room may be made.

The sufficiency of ventilation may also be estimated by determining the amount of air which passes in and out of a room, its floor space and cubic contents, the number of persons to be supplied with fresh air, together with the direction and velocity of air currents within the room and their effect upon the occupants. If there are distinct and special outlets, as by flues provided for the purpose, it will generally suffice to measure the amount of the air passing through them, since the quantity of incoming air will be nearly the same. The quantity of the air passing through these outlets is readily found by multiplying the area of the opening, stated in square feet, by the velocity of the current of air expressed in lineal feet per minute. The product is the delivery of air in cubic feet per minute. Since the rapidity of the air current is very variable, depending upon wind, difference in temperature and other factors, it is evident that a fair average should be made from a number of observations before arriving at definite conclusions. The velocity of the air current is determined by the anemometer, an instrument so constructed that the velocity of moving air is shown by the rate at which it causes a light propeller-like wheel to revolve when placed in its course. The number of revolutions are recorded, in feet or meters, on a fixed dial with which the wheel is connected by

an arrangement of cogs, and may be read off at suitable intervals, usually of exactly one minute. A catch is placed on the rim of the instrument to enable the observer to throw the indicating wheels in or out of gear from the fan, for the purpose of taking short observations with accuracy. In using the apparatus, care should be taken that the air current strikes the fan at right angles with its plane; the instrument being allowed to run for a minute before readings are begun. All these instruments present a certain amount of friction, for which a slight correction must be made. Since the rate of movement of air currents passing through an opening may vary considerably, it is customary to make five readings for each aperture, at different points, and accept the general average as the mean rate of velocity for the whole. As already noted, in calculating the flow of air through an ordinary register a deduction of about three-tenths must be made for the grating.

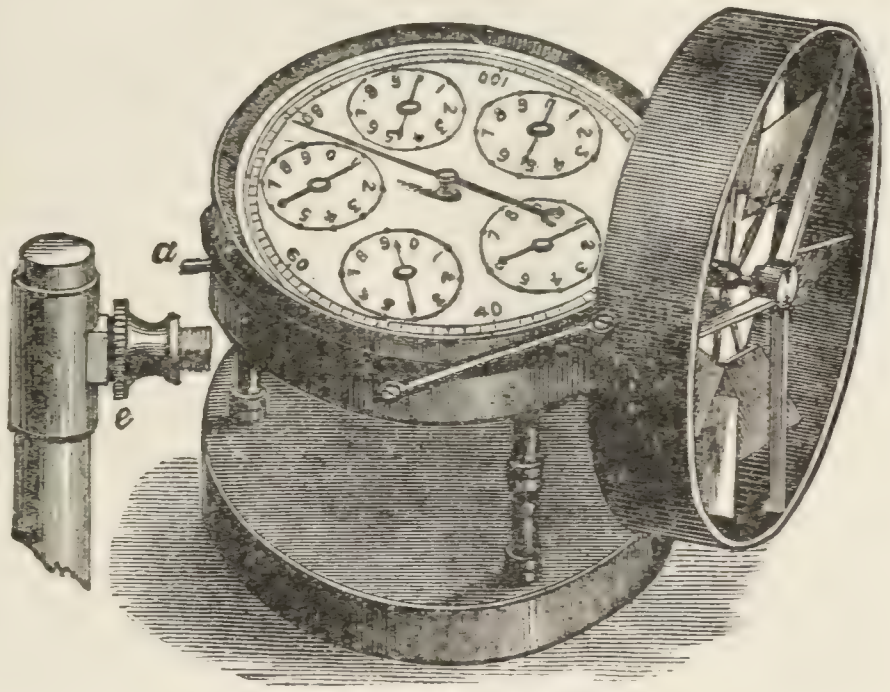


FIG. 238.—Anemometer.

Laveran states that the inclination of a candle flame at an angle of 45°, when placed in a draft, shows the presence of an air current having a rate of 0.4 to 0.5 meters per second. This method may be used for estimating the velocity of air currents when no more exact means are available.

When direct measurement of incoming and outgoing air currents is made the results obtained can be considered as only relatively accurate, because of an indefinite but considerable amount of leakage of air around doors and windows.

To determine the direction of air currents within the room, smoke is commonly used. This may be produced by burning tobacco, cotton velvet or a lamp-wick saturated with benzoin. The fumes of nascent ammonium chloride are in some respects preferable to smoke, since they are of the same temperature as the air. They are produced by pouring a little ammonium hydrate into a capsule, and surrounding this with a sheet of blotting paper pinned in the shape of a cylinder and saturated with dilute hydrochloric acid. Sometimes feather-dust is used to demonstrate air currents; and filaments of floss silk suspended from a rod or from the ceiling furnish a delicate test for the same object. Unless an air current be very weak it, and its direction, may be detected by the moistened finger, through the sensation of cold imparted.

EXAMINATION OF AIR.

For hygienic purposes, in the practical examination of air in the military service, the chief points requiring attention are the manner of collecting the sample and the estimation of the amount of carbon dioxide present. The latter is done roughly by means of the senses, as already described, but much more exactly by chemical procedures. There are other subjects which are sometimes given consideration in connection with the examination of air, such as the determination of the oxidizable and organic matter, the estimation of carbon monoxide, the presence of ozone, the determination of aqueous vapor and an examination of the suspended matter and micro-organisms, but these are not of sufficient practical importance to warrant their being included in a work of this special character.

All air samples should be collected at a time when the pollution of the atmosphere is the greatest, which, in the case of a squad-room, is shortly before reveille. For the actual collection of the samples, large rubber-stoppered jars, holding from five to ten liters, are the most convenient. These are thoroughly cleansed with distilled water before use, inverted to run dry, and stoppered—a label being attached for stating the current temperature and pressure. To fill the jar with the air sample the simplest way is to fill it to the brim with distilled water, invert it and allow it to drain dry in the room, the air of which it is desired to collect. As the water flows out of the jar, air rushes in to take its place. Since water, however, may hold a considerable quantity of carbon dioxide in solution, and since it is scarcely possible to remove at once all moisture from the interior of the collecting jar when the above procedure is employed, many chemists prefer to avoid possible sources of error and to pump the air sample into the jar by a small syringe, the nozzle of which is passed to the bottom of the receptacle so as to displace the contained air upward. At the Army Medical School, before collecting the air sample, the student officers are required to wash the jar with distilled water, to remove all moisture from the jar with alcohol, to remove the alcohol with ether, and finally to remove the ether by vigorous pumping with the air syringe. After filling the vessel, it is at once closed with an air-tight stopper or rubber cap; care being taken that no breath is introduced into the jar before it is stoppered. After stoppering, the label is inscribed with the current temperature, barometric pressure and the cubical capacity of the jar.

The most common and generally satisfactory procedure for the estimation of carbon dioxide is Pettenkofer's alkalimetric method. This depends upon the fact that clear lime-water or baryta-water, both of which are strongly alkaline media, will readily absorb and neutralize carbon dioxide; the absorption of this weak acid diminishing by so much the alkalinity of these media. If, therefore, the degree of alkalinity of either of these solutions be known both before and after exposure to the carbon dioxide, the difference will represent the amount of CO_2 which has combined with the lime or baryta in the formation of a carbonate. The practical details of the process are given by Smart as follows:

An oxalic acid solution is made by dissolving 2.864 gm. of the acid in one liter of distilled water, 1 c.c. of this solution being equivalent to 1

mgm. of CO_2. A caustic baryta or lime solution, of equivalent strength, is then made up. This alkaline solution is stored until required for use in small bottles, holding about 60 c.c. each. The latter are then tightly corked, weighed, and the weight of each filled bottle is marked on its label. The air sample having been collected in a suitable container, the contents of one of the lime or baryta-water bottles is poured into the collected air, and the container is closed with a rubber cork or carefully ground stopper. The temperatures by the wet and dry bulb thermometers and the barometric pressure are observed, and are marked on the jar containing the air sample. The air container is then shaken and allowed to stand until the following day, if lime is used; or with baryta-water it is shaken and revolved for fifteen minutes, at the end of which time the formation of barium carbonate may be considered to be effected. The quantity of baryta solution introduced into the air container is obtained by re-corking and weighing the bottle in which it was stored, and deducting this weight from the gross weight marked on the label. The loss of weight in grams equals the number of cubic centimeters of the baryta or lime solution transferred to the bottle containing the air sample. This number of cubic centimeters must then be deducted from the known capacity of the jar.

But in order that the experimental results may be susceptible of comparison, it is necessary to express the air volume in the space which it would occupy when dry at 0° C. and under a pressure of 760 millimeters of mercury. Increased pressure diminishes the volume of air, while increased temperature expands it; and the pressure of the watery vapor present must also be taken into account. The temperature observations furnish the dew point, and through it, from the observations of Regnault, the pressure or tension of the aqueous vapor may be obtained. If p represents this pressure, t the temperature in Centigrade degrees, b the barometric height in millimeters and V the capacity of the jar, minus the number of cubic centimeters of baryta solution introduced, the corrected volume will be equal to—

$$\frac{V\ (b-p)\ 273}{(273+t)\ 760}$$

If the observations have been made on the Fahrenheit scale and in barometric inches, the formula is—

$$\frac{V\ (b-p)\ 491}{29.92\ (491+dt)}$$

in which dt is the number of degrees between 32° F. and the observed temperature.

To test the causticity of the baryta water after being shaken with the air sample, 20 c.c. are removed from the jar, phenolphthalein solution added to it in a beaker and the oxalic acid solution slowly titrated in from a burette until the red color is discharged. The loss of alkalinity in cubic centimeters equals the number of milligrams of CO_2 in the 20 c.c. of the solution tested; from which the CO_2 absorbed by the whole of the baryta solution may be calculated, equalling the same number of milligrams of CO_2 in the sample of air collected. The weight of the CO_2 is then converted into volume by multiplying by 0.573, and for purposes of

comparison it is calculated into volumes per 10,000 of the corrected air. It must be mentioned, however, that the volume of carbon dioxide found by this process is not all carbonic impurity, but includes also that naturally present in the atmosphere. When the result of a contemporaneous analysis of the external air has been deducted from it, the remainder will indicate the carbonic impurity due to imperfect ventilation.

For general military purposes a convenient method for estimating the amount of carbon dioxide present is that proposed by Smith; for which there will be needed six well-stoppered bottles, containing respectively 450, 350, 300, 250, 200 and 100 c.c., a glass pipette graduated to contain 15 c.c., and a bottle of perfectly clear and transparent fresh lime-water. The bottles should be thoroughly clean and dry. Having pumped the bottles full of the air to be examined, by means of a small bulb syringe, 15 c.c. of the lime-water are placed in the smallest bottle by means of the pipette; the bottle being tightly stoppered and the whole vigorously shaken. If the lime-water presents a turbidity, the amount of carbon dioxide present will be at least 16 parts in 10,000. If no turbidity appears, the next sized bottle—of 200 c.c. capacity—is treated in like manner. Turbidity in this would indicate 12 parts of carbon dioxide in the ten thousand. If this remains clear, but turbidity is produced in the 250 c.c. bottle, it marks about 10 parts per 10,000. The 300 c.c. bottle indicates 8 parts, the one of 350 shows 7 parts and the one of 450 less than 6 parts per 10,000. To judge of the turbidity, a small piece of paper is marked with a cross in lead pencil, and gummed with its face to the side of the bottle on the lower part. When the water becomes turbid, the cross will be invisible when looked at through the water. This test is so readily carried out as to be specially adapted to the needs of the military sanitarian.

CHAPTER XI.

HEATING AND LIGHTING.

I.

HEATING.

General Considerations.—Heat is required to maintain the air of barracks at a suitable temperature, to make good the loss of heat due to its radiation and conduction from windows and walls, and to supply warmth to the air required for ventilation. The amount of heat necessary for these various purposes will depend largely upon the outside temperature, the construction of the building and its exposure, and the supply of air needed for the maintenance of proper ventilation. The warming of barracks is not satisfactorily accomplished unless the temperature is sufficient and is uniform for time and space; the physical properties of the air, especially its moisture, are maintained; the atmosphere is not vitiated by the products of combustion or by dust; and unless the heat contributes to the accomplishment of ventilation. In addition, the apparatus for the generation and distribution of heat should be simple in construction, economical of fuel and labor in its operation, and be free from the dangers of fire or explosion.

The heat evolved in the combustion of fuel is given off to surrounding bodies by conduction, by radiation and by convection. Conducted heat passes from one particle of matter when they touch, or are separated only by insensible distances. Heat is conducted through all solids, which vary greatly in their conductivity, but is transmitted only to a very limited degree by liquids and gases. Thus the conducting power of copper in respect to heat is given as 20,150 times greater than that of air, and 554.1 times greater than that of water. Bodies which are good conductors rapidly give off their heat to the surrounding air or to anything in contact with them, and in like manner, if colder, they withdraw heat from other bodies.

Radiation is not only the most common but also the most wasteful of the ways by which heat is distributed. Radiated heat is propagated from its source in straight lines and with equal intensity; the effect decreasing according to the square of the distance. Radiant heat is reflected like light from solid bodies, but some of the heat is absorbed; the amounts reflected and absorbed being in inverse proportion to each other, and largely dependent upon the surface, color and nature of the object, as well as upon the difference of temperature between the receiving and radiating bodies. The convection of heat is that mode by which heat is chiefly propagated in liquids and gases, and is dependent on the characteristic of those bodies by which such portions of them as have become heated expand and rise,

their place being at once taken by the colder parts. A species of circulation is thus established and the whole mass of liquid or gas is soon warmed. Every person in a room causes convection currents by the heat conducted to the air in contact with his skin or clothing; while the air of a heated room, from a similar cause, is in a state of active movement. The convection currents produced by fires, and by the human body in an atmosphere colder than itself, not only carry off some heat but also provide the body with a supply of fresh air. When the temperature of the surrounding air is nearly that of the body, this natural replacement of air does not occur; requiring the production of artificial air-currents for comfort. An idea of the relative efficiency of radiation and convection, in the accomplishment of heating, may be gained by placing the hand alongside a lamp flame and then above it; this simple test readily showing that far less heat is lost by radiation than is carried away by ascending air-currents. This explains the deficient heating qualities of the ordinary open fireplace; since only radiated heat is utilized by this means, while the air heated by the fire passes up through the chimney and escapes from the building. The sensations produced by radiated and convected heat are also quite different; radiant heat warming only the side exposed to the source of heat, while the air warmed by convected heat has an equal effect on all sides.

The heating of a room is technically said to be effected by direct radiation, by indirect radiation, by direct-indirect radiation, or by combinations of these methods. In this sense, direct radiation means that the heating surfaces are placed in the room to be warmed and are not connected with the air supply, so that the incoming air is not warmed. This method is clearly not satisfactory. Indirect radiation means that the room is heated by air which has been warmed by being brought into contact with heated surfaces placed in some other room, usually in the basement or cellar. Direct-indirect radiation means that the heating surfaces are in the room to be warmed, and have outside fresh air brought around them to be raised to the desired temperature. At present, in our new barracks, heating by direct-indirect radiation is the method usually employed. Whatever be the special method of heating adopted, it is obviously desirable that the warming of air in a room should be accomplished at its coldest point.

In practice, the problems of ventilation are very closely connected with those of heating; since heat is one of the important agents in accomplishing ventilation, and the distribution of heat is commonly dependent upon the distribution of heated air or water. All waste heat should be utilized in securing a proper renewal of air; and thus, even in hot weather, a little ingenuity may convert heat, generally so annoying, into a valuable power for cooling down the air of a building. The combined action of heat and air-currents is of much importance in maintaining the proper dryness of habitations.

The unit of measure of heat commonly employed in this country is known as the British heat unit, and is that quantity required to raise one pound of water one degree Fahrenheit; another unit of measure is the Calorie, representing the amount of heat required to raise one kilogram of water one degree Centigrade. It is sometimes convenient, in ventilation

and heating problems, to express the amount of heat in terms of force. When so expressed, the British thermal unit is equal to 772 foot-pounds of force, and the Calorie is equal to 423.985 kilogram-meters; each kilogram-meter being equal to 7.2 foot-pounds and one Calorie being equal to 3.968 Fahrenheit units. The calorific power of any combustible is represented by the number of heat units (or Calories) which one pound (or kilogram) is capable of developing on being burned. Assuming that the volume of air is constant, the following table from Billings shows the number of thermal units required to heat a given volume of dry air a certain number of degrees Fahrenheit, commencing at 32° F.

Cubic feet.	Heated.								
	1°.	2°.	3°.	4°.	5°.	6°.	7°.	8°.	9°.
100	1.92	3.84	5.76	7.68	9.60	11.52	13.44	15.36	17.28
200	3.84	7.68	11.52	15.36	19.20	23.04	26.88	30.72	34.56
300	5.76	11.52	17.28	23.04	28.80	34.56	40.32	46.08	51.84
400	7.68	15.36	23.04	30.72	38.40	46.08	53.76	61.44	69.12
500	9.60	19.20	28.80	38.40	48.00	57.60	67.20	76.80	86.40
600	11.52	23.00	34.56	46.08	57.60	69.12	80.64	92.16	103.68
700	13.44	26.88	40.32	53.76	67.20	80.64	94.08	107.52	120.96
800	15.36	30.72	46.08	61.44	76.80	92.16	107.52	122.88	138.24
900	17.28	34.56	51.84	69.12	86.40	103.68	120.96	138.24	155.52

From this table it is easy to calculate the amount of heat in thermal units required to raise the temperature of any given volume of air through any number of degrees of temperature.

The freer the ventilation, the greater the amount of heat which naturally must be supplied to maintain the desired degree of warmth. A common method of determining the number of heat units required for ventilation consists in multiplying the number of cubic feet of air required during a given time by the difference in temperature between the warm and outside air, and then dividing by 55. This last number is used as a divisor, since in absorbing one heat unit 55 cubic feet of air will be warmed 1° F.; and thus this quantity of air may be considered as equivalent to a pound of water as far as the transmission of heat is concerned. The heat capable of being stored or retained in a substance is called its specific heat, and this quality of holding heat becomes of material importance in connection with the warming of buildings. This specific heat is usually described as being the units required to raise the temperature of one pound of the substance under consideration through 1° F. Thus one pound of water requires one British thermal unit to raise its temperature 1° F.; a pound of steam requires 0.480 of a thermal unit; a pound of expanding air requires 0.238; and air having a constant volume requires 0.169. Weight for weight, water is thus seen to absorb more heat from the same rise of temperature than any other substance; and hence the economy in the use of water as a carrier of heat, as compared with air, is evident.

The loss of heat from buildings, irrespective of that naturally depending on ventilation, is often very great and should properly be anticipated in the establishment of heating arrangements. The determination in advance of the loss of heat through the walls and windows of any given

building or room is, however, a problem practically impossible of theoretical solution. Clearly no exact figures or rules can be given on this point; for the loss of heat from a barrack depends, among other factors, upon the kind of material used in its construction; the thickness of the walls, and whether they are single or double; the quality of the workmanship; the number and size of windows; and the orientation of the building and its exposure to prevailing winds. Reliable conclusions as to the probable loss of heat can be arrived at only by the proper consideration of all the factors in the case, fortified by knowledge born of long experience. In all buildings there is a considerable loss of heat from the crevices around windows and doors, and in limiting loss in this manner weather-strips should always be used on barracks in cold climates. These weather-strips generally consist of slips of metal embracing a narrow band of rubber; but sometimes strips of wood bordered with closely woven felt are used. These strips are nailed on all sides of the window-frame, making tight joints against the sashes. In bitter cold weather, when a high wind fairly blows the heated air out of barracks, these contrivances prevent such action to so great an extent that rooms otherwise uninhabitable become warm and comfortable. Reference has already been made to the great diminution in the loss of heat which results from the use of double window sashes.

Although a matter of much importance, the equable distribution of heat through a closed space, together with the maintenance of a proper temperature over considerable periods, is not readily accomplished. This is particularly the case when the external temperature is constantly varying, the barracks are of a poor construction, the rooms have high ceilings and stoves or open fireplaces are used. Heating by hot-air furnaces gives better results; but the entering warm air tends to rise, and thus forms a series of layers of air increasing in temperature toward the ceiling. With poor floors, this upward movement of heated air causes a great difference in the temperature at the floor and ceiling; and it has already been mentioned that at one northern station a variation of 30° F. was noted between the temperature taken at the floor level and at a point six feet above it. Under such conditions the feet and legs are kept constantly cold by chilling air-currents. Undoubtedly the best plan of heating a squad-room so as to secure equability of temperature is by the direct-indirect method; the radiators being placed around the room under the windows, which are the points of greatest diathermancy. It is especially important that hospitals and guard-houses be evenly heated throughout, since it is plain that patients or prisoners will rarely be able to leave their beds or cells to get nearer to the sources of warmth. An equable temperature extending over considerable periods, however, is obviously unnecessary in places used intermittently, as drill halls. Such places are generally warmed up immediately before they are used, and the fires subsequently allowed to die down. There is some economy in this; but the saving is not so great as at first thought might be supposed, from the necessity of overcoming the chilling which takes place between periods of heating. In this connection it is interesting to note that in the French army, on account of the scanty supply of fuel allowed, certain fires are not maintained in barracks throughout the night, but are carefully extinguished except in the coldest weather.

The temperature of barracks is best maintained at 66°–68° F. Billings

suggests a temperature of 70° F.; but this is slightly higher than is necessary for the comfort of troops and is more applicable to hospitals. The temperature in gymnasia and drill-halls need not be above 45° F. Soldiers will not stay in barracks any longer than necessary if these be not sufficiently heated, but will seek resorts where there is plenty of warmth—and such resorts, if outside the garrison, may not be elevating in their influences. Guard-houses require to be particularly well heated, so that soldiers returning from tours of sentry duty may be able quickly to dry out their wet garments and warm their chilled members. On the other hand, over-heating of squad-rooms is always to be avoided. Soldiers are prone to allow this, particularly colored troops, and when coming from over-heated rooms into the cold outside air they are liable to become chilled, with resulting congestive disturbances. Hence the temperature of the squad-room should be regulated by the thermometer and not by the preferences of its inmates; and constant oversight, in this respect, should be had by non-commissioned officers. Kitchens are particularly apt to become over-heated, and the men employed therein are exposed to frequent and extreme changes of temperature. To limit over-heating, a hood should always be constructed over the range, having a ventilating flue discharging directly into the open air and thus carrying away the heat. This arrangement also serves an excellent purpose in getting rid of cooking odors, without their being carried on outgoing air-currents to be distributed all over the building. Where such an arrangement is used, the flow of air is directed from the building into the kitchen instead of out of it.

Air usually contains a considerable amount of moisture; its capacity for taking up such moisture increasing as its temperature is elevated. Coulier states that a cubic meter of air, under a pressure of 760 millimeters of mercury, is saturated with watery vapor at 10° C. when holding in suspension 9.7 grams of water; while at 25° C. it would require 22.5 grams to effect saturation. Hence cold outside air which has been warmed and admitted into barracks is deficient in moisture, and this must be artificially supplied. Should this be not done, the undue dryness of the air causes harshness of the skin, irritation of the air passages, thirst and dryness of the throat and fauces. With such air there also appears to be a tendency toward the occurrence of tonsillitis. That all these conditions are entirely due to over-dryness of the air there is some doubt; probably the symptoms of irritation of the respiratory tract are dependent more upon the fine dust, largely composed of minute fragments of dry wood ground from the floor by the feet of passers, which acts mechanically as an irritant to the mucous membranes, and which is much less liable to be taken up by moist air. It is generally accepted that where a considerable number of persons are living together, the amount of moisture directly provided should be about fifty per cent., since the human body itself gives off much watery vapor. De Chaumont recommends, for squad-rooms, that the difference between the readings of the wet and dry-bulb thermometers should not be less than four nor more than five degrees Fahrenheit. To supply the necessary moisture, with steam-heat a little watery vapor may be allowed to escape into the air of the room. Furnaces are apt to deliver their hot air in too dry a state, and the condition of their evaporating pans, as to a supply of water, should be closely attended to. Where heating

stoves are used, a flat dish of water is usually set upon them; but no provision of this character is made in the barrack stoves of the models chiefly furnished in our service. Too great moisture in the air of a heated room is productive of much discomfort, since it interferes with the proper removal of body moisture by respiration and cutaneous evaporation.

Fuel.—The production of heat for the purpose of warming and ventilating buildings is commonly effected by the combustion of fuel. The chief constituents of fuel are carbon and hydrogen, with various chemical combinations of these two elements, while their principal products of combustion are CO_2 and H_2O. The amount of heat produced in the combustion of a fuel is approximately the sum of the quantities of heat which the hydrogen and carbon contained in it would produce separately by their combustion. When hydrogen and oxygen exist in a compound in the proper proportion to form water, these constituents have no effect on the total heat of combustion, and it is only the surplus of hydrogen above that which is required by the oxygen which is taken into account. The heat of combustion for one pound of pure carbon is given by Notter and Firth as 14,500 British heat units, and that of one pound of pure hydrogen as 62,032. From these principles and data is deduced the following general formula for the total heat of combustion of any compound, of which the principal constituents, carbon, hydrogen and oxygen, are known:

$$h = 14{,}500 \left\{ \mathrm{C} + 4.28 \left(\mathrm{H} - \tfrac{\mathrm{O}}{8} \right) \right\}$$

in which h is the total heat of one pound of the compound in British thermal units; C, H and O are the fractions of one pound of the compound consisting respectively of carbon, hydrogen and oxygen, while 4.28 is a constant deduced from the ratio of 14,500 to 62,032.

To calculate the quantity of air required for the combustion of any given fuel, the following formula is used:

$$12\ \mathrm{C} + 36 \left(\mathrm{H} - \tfrac{\mathrm{O}}{8} \right)$$

This is based on the fact that 72 parts by weight of air represent 16 of oxygen. The weight of air theoretically necessary is therefore 12 times that of the carbon + 36 times that of the hydrogen, less $\frac{9}{2}$ that of any oxygen which may be present in the fuel itself. If the unit employed be one pound, the volume of air at 32° F. may be found by multiplying the weight of air, obtained by the formula, by 12.844, this being the volume in cubic feet which one pound of air occupies at that temperature. In actual practice, half as much again to twice this amount of air is found to be necessary.

In the United States service, the cord of merchantable oak wood is the standard upon which all issues of fuel are based; a scale of equivalents, determined by comparative efficiency in the evaporation of a given weight of water, being published from time to time. At present, the heating equivalents of one cord of oak wood are laid down as follows:

Yellow pine	$1\frac{1}{5}$	cords.
White pine, poplar or cottonwood	$1\frac{1}{3}$	"
Spruce or birch	$1\frac{1}{2}$	"
Charcoal	1,706	pounds.
Coke	1,707	"
Anthracite coal	1,700	"
Bituminous coal	from 1,500 to nearly 4,000	"
Lignite	from 2,500 to 3,000	"

A large variety of bituminous coals are purchased for issue, and these differ very greatly in their heating qualities. Usually a coal mined nearest to a garrison is the one employed. Charcoal was issued to troops in Cuba, but its cost was so great that coal and wood were substituted. Coke is little used.

For fixing the allowance of fuel for heating purposes, the United States is divided into several zones. Below the 36th degree of latitude, each non-commissioned officer and private is entitled monthly to one-twelfth of a cord of oak wood or its heating equivalent, during the period May 1 to August 31; and to one-sixth of a cord from September 1 to April 30. Between the 36th and 43d degrees of latitude the fuel allowance of the soldier is increased by one twenty-fourth of a cord monthly, from September 1 to April 30; while north of the 43d parallel the allowance is increased by one-eighteenth. To provide for the needs of particularly cold posts, it is ordered that in stations situated between the 36th and 43d degrees of latitude, where the mean temperature during twenty days of any calendar month is not above 20° F., an increase in the allowance of fuel of one-third instead of one-fourth, as given above, is authorized. If the temperature is not above 10° F. for twenty days in any calendar month, an increase of one-half will be allowed, whatever be the latitude of the place. Under all circumstances, a company is allowed sufficient fuel for the proper cooking of its food. Fuel is regarded as public property and not as an allowance, and any unused portion of such as may have been issued to troops is required to be turned back to the quartermaster.

Regulations state that the cheapest fuel at the place of issue will, all things being considered, be furnished to troops. This may at times work no great harm; but in very cold climates the restriction of a garrison to fuel of an inferior quality, merely because it is slightly cheaper, may be a serious hardship. For troops in the northwest to be required to burn the inferior grades of bituminous coal and lignite mined in the vicinity is undesirable. Such coal, as that supplied at Fort Assiniboine, gives off comparatively little heat and burns out quickly. It leaves a large amount of refuse; often in the nature of slag which has been melted down by the heat and is not readily removed. The ashes require to be frequently shaken out of the grate, and the ash-pit emptied, with resulting dust. Further, the fuel contains much sulphur; and the fumes of sulphur dioxide which escape into the room, particularly when the stoves are imperfect or hot ashes are being removed, are often highly irritating to the respiratory tract. The smoke produced by coal of this character is very dense, and the chimneys require frequent cleansing of soot to ensure their proper operation. Fires maintained by such fuel require constant attention and imply greater labor of administration; since much more fuel is required to produce a given result, and in the combustion of such coal an excessive proportion of ashes remains to be removed. All things considered, it may fairly be questioned whether the use of the lignites and the lower grades of bituminous coal results ultimately in much greater economy than if anthracite were issued; this being undoubtedly the fuel most adapted to the needs of the military service. The latter coal is cleanly and easy to handle, and contains a high proportion of heat latent in a given weight. Little smoke or fumes of sulphur are given off, and the resulting ash is

comparatively small in quantity. White-ash Lehigh stove-coal gives the best results in stoves and small furnaces; for large furnaces a mixture of stove and small egg-coal is best employed, since the fire can be better regulated and controlled by its use.

Wood is still used as fuel at certain stations. Its heating power varies with the amount of moisture which it contains. Green wood may contain as much as forty-five per cent. of moisture, and part of the heat produced by combustion is lost in the vaporization of the latter. Well-dried wood contains but fifteen to twenty per cent. of water; and when wood of this character is used, fires are readily started, the fuel is consumed rapidly and much heat is given off in a short space of time. A practical drawback to the use of wood, therefore, consists in the great difficulty of maintaining an even temperature in rooms heated by its combustion. Wood soon burns out, the supply of fuel has to be frequently renewed, especially with pine or other soft wood, and squad-rooms heated in this manner are liable to become very cold at night during severe weather.

As already intimated, the total heat given out during the combustion of various kinds of fuel varies greatly, and this is a practical point which should be given consideration in connection with heating arrangements. Further, the heat which can be evolved from different specimens of the same class of fuel varies so greatly that a definite knowledge of the heating value of the special kind to be used should be had before any plans for the heating of barracks have been matured. Estimates which have been made of the heating value of various fuels are as follows:

Fuel.	Fuel value of one pound, Calories.
Charcoal	3,430
Coke	3,467
Anthracite	4,097
Bituminous coal	From 1,804 to 4,643
Lignite	2,990
Dry wood	1,830
Petroleum	5,538

The choice of a fuel of course has a close relation to the nature of the heating apparatus available, and vice versa. This would seem so evident as scarcely to require mention; yet at Fort Assiniboine, for instance, after the abandonment of anthracite coal for the local bituminous supply, the stoves intended for the combustion of hard coal were largely left in use and naturally proved of little value for purposes of heating with the new fuel.

While the issue of fuel in our service depends upon the number of individuals in an organization, in the British army a more rational method is employed and the fuel allowance is based upon the size of the space to be heated, irrespective of the number of its occupants. At present, in that service, 40 pounds of hard coal are allowed daily for the heating of 7,200 cubic feet. If the space to be heated is of less size than this, a reduction is made; but since the consumption of fuel in small spaces is proportionately greater, the fuel allowance is not reduced quite to the same extent. When troops are in huts, the above allowance of fuel is increased by one-third; and special issues of fuel may be authorized by commanding officers during cool or damp days in summer. The allowance of fuel in the French

army is based, like our own, primarily upon temperature as depending upon latitude—the country being divided for the purpose into five zones. The allowance is made per man and not per cubic space. Usually seven kilograms of wood are allowed daily for each authorized stove; but supplementary issues of fuel are authorized during periods of great cold. As in our own service, no official allowance of fuel is laid down for hospitals in the French or British army, but they are heated according to existing circumstances so as to maintain a constant temperature of about 65° F.

The allowance of fuel authorized in our service is often insufficient for the proper heating of barracks at northern stations, though adequate for those further south. Clearly an allowance of fuel which might be sufficient for the heating of a well-built barrack warmed by steam-heat, might be quite insufficient to maintain a proper temperature throughout an old, poorly constructed building, heated by stoves of rapid combustion. Where squad-rooms are smaller and more numerous, and stoves are used, the loss of heat is proportionately greater and the deficiency in fuel rendered even more apparent. To secure the best results with respect to heating, it would seem that each barrack in a post should be considered separately, and the amount of fuel required for its proper warming should be fixed by the commanding officer. In respect to fuel, as in some other matters, a greater elasticity of the regulations governing its issue would be of advantage. With regard to officers, present regulations concerning the purchase of fuel by them are not equitable. A limited supply only, graded according to the rank of the officer, can be purchased at the fixed government rates; any excess being charged for at full contract prices. For very cold stations and for officers of lower rank the official allowances are in practice quite insufficient; and thus junior officers serving in northern stations are doubly placed at a financial disadvantage as compared with those stationed in warmer localities. As a matter of justice an officer serving anywhere, irrespective of rank, should be allowed to purchase at fixed rates such fuel as he might certify was required for his own use, as is at present allowed in the case of mineral oil, commissary stores and clothing.

Local Heating.

Barracks are warmed either locally or by heat distributed from some central point. By the first method, heat is furnished by the combustion of fuel in the room itself, either in fire-places or in stoves. The heating is obviously very unequal, and the temperature throughout a barrack building warmed in this manner usually varies greatly. The system also has very many other defects, which are discussed subsequently. In the French army the local method of heating is the only one employed at most stations, since the allowance of fuel is so small as to be quite insufficient for the heating of an entire barrack building, and hence only certain portions of it are warmed. Clearly such motives of economy need not stand in the way of the general heating of barracks in our service, and local heating should be used only under such special conditions as may render it more desirable or practicable.

Open Fire-Places.—The use of ordinary open fires and grates is a

most costly and imperfect method of heating, since these practically give out only radiant heat—though it must be understood that objects warmed by radiant heat do, in turn, themselves convey heat to the layers of air with which they come in contact. It has been shown by Morin and others that with ordinary open fires but six per cent. of the total heat latent in wood is secured for the warming of an apartment—the rest of the heat being carried up the chimney or escaping as unconsumed carbon. Under the same conditions, coke yields to warming purposes but twelve per cent. of its theoretical fuel efficency, and coal about thirteen per cent. The chief sanitary advantages of open fire-places are found in the fact that ordinarily the air of the room heated by their use is not contaminated by the products of combustion, nor is it scorched or dried to any extent. Ventilation is also very free, so much so as at times to present serious disadvantages—since immense quantities of air, far greater in amount than is required for the combustion of the fuel, are drawn up the chimney, which acts as a heat-extraction shaft. Notter and Firth state that from 20,000 to 40,000 cubic feet of air, or more, may thus be removed in the course of an hour by an ordinary fire-place—the quantity varying with the difference between the internal and external temperatures, the size and height of the chimney and the size of the fire itself. To replace this loss of air it is evident that an equal quantity must be drawn into the room. If the incoming air were warm, the liberal ventilation thus assured would be excellent; but unfortunately this is usually cold, and finds entrance through crevices around the doors and windows or in the floor. This gives rise to numerous knife-like drafts of a particularly chilling character, which increase in intensity with the degree of outside cold and the size of the fire maintained. The entering air is constantly moving toward the chimney shaft, and thus causes cold currents on the backs and legs of persons who may be sitting before the fire, and who may at the same time be uncomfortably warm on the portions of the body directly exposed to the radiated heat. When efforts are made for the diminution of this entering air, down-drafts are almost certain to be created in the chimney; driving smoke and gases into the room and forcing the admission of the necessary amount of cold air as the lesser of the two evils. Though this fault may be partially controlled by regulating the chimney current with a damper, it is nevertheless clear that with ordinary open fires it is impossible to warm an apartment equally, even under the best of circumstances. A minor advantage of open fires is the cheerful blaze which they afford; but with fuel of poor character the fact that the fire is not enclosed renders the possibility of accidental conflagration much greater.

In the construction of open fire-places, it is evident that the materials employed should be poor conductors but excellent radiators of heat. The chimney flue should be as small as possible, the fuel surface should be concentrated and set well forward, the side walls of the fire-place should join the back at an angle of 45°, so as to throw as many heat-rays as possible into the room, and for the same reason the top should be inclined forward from the back at an angle of about 55°. There should also be a damper in the chimney, so as to limit the amount of hot air passing up it and consequently the entrance of cold air into the room from outside. To get the best results, Morin recommends that the temperature in the chim-

ney of a fire-place be maintained at least 80° F. above that of the open air, that smoke should not issue from the chimney at a rate greater than ten feet per second, and that the outlet of the smoke-flue should have an area one-half that of the flue just above the fire-place.

Ordinary open fire-places are obviously not satisfactory for the heating of barracks; but for winter quarters or where troops are in huts, and no special facilities for heating are provided, as was frequently the case during the Civil War, they may readily be improvised and will prove of much service under such conditions.

To minimize the defects of the ordinary open fire-place, as just described, certain modifications of structure have been proposed by which a portion of the escaping heat is utilized in warming the entering air. The general principle of these changes, as exemplified in the Galton grate, is shown in Fig. 215. Briefly, the modifications consist in carrying the heat and smoke from the fire through a chimney passing through an air-chamber, built behind and over the fire-place. This air-chamber opens at its lower part into the external air, and from its higher part into the room by an air-shaft which discharges near the ceiling. The air from outside, on entering this chamber, becomes warmed by passing over the heated back of the fire-place and smoke-flue, and then passes on to enter the room. The movement of the air after entering the room is shown in the illustration just mentioned. It is stated that a ventilating fire-place of this general pattern is capable of utilizing for purposes of warmth about thirty-five per cent. of the available heat in the fuel consumed, or about three times as much as with fire-places of the old model. The Joly fire-place, Jackson grate and Griffith grate are all slight modifications of the Galton grate just referred to. Ventilating fire-places have been used to some extent in our service; chiefly in hospitals, and particularly in the form of the Jackson grate. They work very successfully in climates where the temperature does not go much below the freezing point; but in zero weather they are unable properly to heat the entering air and the rooms become unbearably cold. The French use them for the heating of barracks at warmer stations, and in the British service their use is the general rule in home garrisons. One Galton grate is the usual allowance, in the British service, to a room containing twelve men or a fraction of that number; the hot-air duct provided generally having a clear area of one square inch to each 120 cubic feet of room space.

When ventilating fire-places are used under the conditions of climate to which they are suited, they give excellent ventilation without drafts, and, as compared with ordinary fire-places, reduce the amount of air aspirated from a room, from the lowering of the temperature in the chimney which is thus brought about. The temperature of the room, from the movements of the entering warm air, is rendered quite equable, and smoking of the chimneys is infrequent. If desired, one room over another may be heated from a single fire-place on the lower floor, on the principle seen in the well-known "Baltimore heater." In ventilating fire-places, the chamber for the warming of entering air should be large, and, as shown in the accompanying illustration of the Jackson grate, may be advantageously fluted to increase the heating surface as much as possible. Provision should be made by which this air-chamber can be cleaned out as desired.

The exact manner of admitting the air depends on local conditions, as does also the size of the air-shaft. It is important that the entering air should not pass over any iron surface which may be raised to a red heat, on account of the bad odor which results from scorching of the minute particles of dust constantly present in the atmosphere, and from the possibility of the passage of carbon monoxide through the heated metal, or its production from the carbon dioxide of the air through contact with a red-hot surface. The chimney of the fire-place should be furnished with a damper, so that its discharge may be modified in cold weather. Such fire-places work best when the windows and doors of the room are closed; the volume of warmed air yielded by them varies, to some extent, with the direction of the wind.

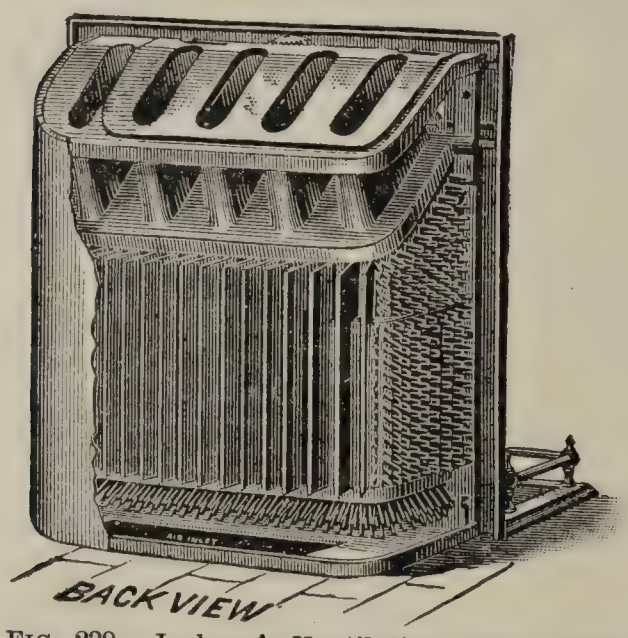


FIG. 239.—Jackson's Ventilating Grate, Back View. The outer casing is cut away to show space and surface for warming the incoming air.

Since architects in this country are not accustomed to put this mode of heating in their plans, its installment after erection of the building implies the demolition of chimneys as already constructed.

Stoves.—Like open fire-places, stoves may be simple heaters or may be so constructed as to contribute to the ventilation of the spaces they are intended to warm.

In stoves of the simplest construction the fire is surrounded directly by the surface to be heated, which, placed unprotected in the room, radiates heat and warms the air by direct contact. The air necessary for combustion of the contained fuel is drawn directly from the room, while the smoke is conducted away to the chimney. No special style of stove is regulation in our service, and a large number of patterns are now in use; the special variety requested by the quartermaster of a post being usually approved for issue. Where the matter of selection is left to the supply department, however, the "Pluto" and "Triumph" models are usually furnished; these being powerful heaters of a simple pattern very suitable for use in squad-rooms. These stoves can be adapted to either hard or soft coal and possess many points of merit. Their greatest disadvantage consists in the absence of any provision by which the necessary moisture can be imparted to the

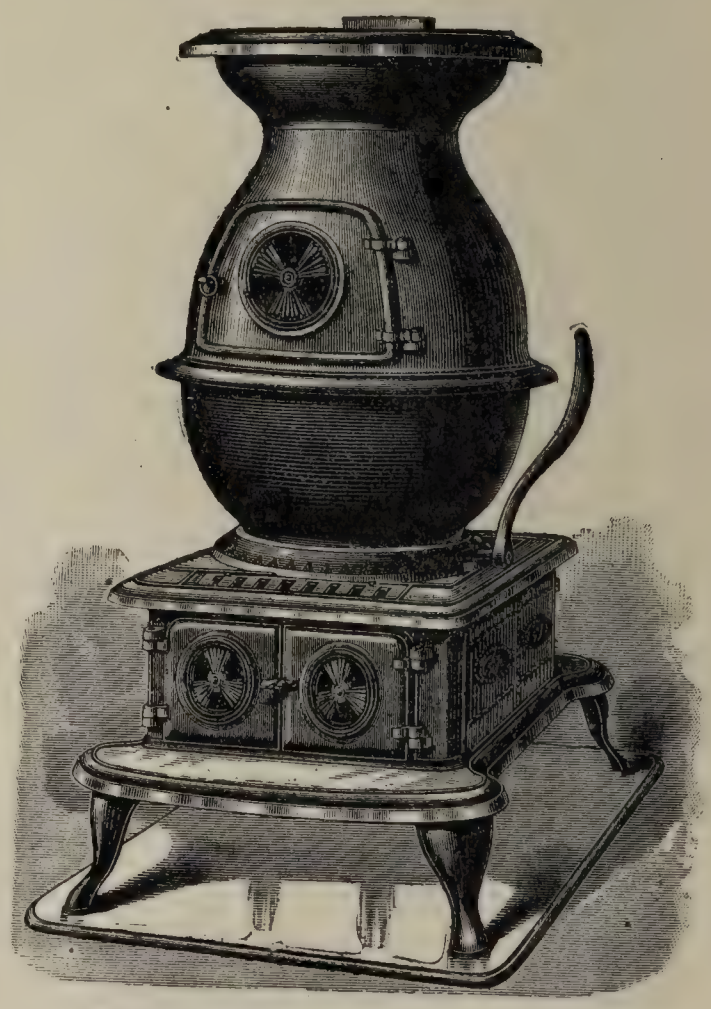


FIG. 240.—The "Pluto" Barrack Stove.

heated air. This is a point which might easily be remedied by some simple improvised arrangement, but in practice it rarely is. Smaller stoves are generally issued for officers and quarters. When anthracite coal is used, these smaller stoves are generally self-feeders; the fire being automatically fed from a coal magazine above, instead from the side by a fire-door, and thus reducing the amount of attention required. Wood stoves are still used at some western stations—as at Fort Yellowstone—where fuel of this sort is abundant and coal can scarcely be supplied on account of the great cost of its transportation. A number of varieties of wood stoves, like those for coal, are supplied for issue.

The official allowance of stoves for a company is two large stoves for the squad-room, one large stove in each mess and day room, and one small stove for each of the two rooms for non-commissioned officers. For each six civilian employees, or for each room occupied by them as quarters, one heating-stove is allowed. With the old company strength of sixty men, it was entirely a question of climate and barrack construction as to whether the above allowance was sufficient. Under some circumstances the authorized allowance of stoves was certainly inadequate, but in practice there was usually no difficulty in obtaining the number required. With the enlargement in the company strength to about double its former number, the official allowance should be proportionately increased. When stoves are used in officers' quarters there is rarely any trouble in obtaining the number desired; though this, in cold climates, is almost invariably much in excess of the official allowance.

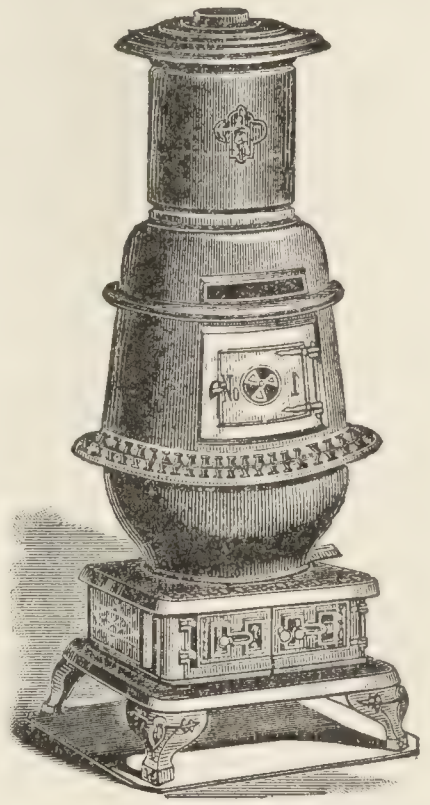


FIG. 241. — The "Triumph" Barrack Stove.

Stoves are economical in fuel in proportion to the heat evolved for warming, and the quantity of heat which passes up the chimney is relatively small. Ordinarily, stoves of rapid combustion utilize about 60 to 65 per cent. of the heat available in the fuel, and those of slow combustion utilize from 80 to 90 per cent. When the draft is too free, considerable wastage of fuel results; Gautier having shown that the heat available for warming, with different kinds of fuel, is nearly twice as great when only the amount of air actually required for combustion is admitted to the stove as when an amount of air twice as large as is necessary is allowed to pass through the fire. Where the stove-pipe is carried some distance across a squad-room, much of the heat which would otherwise escape with the products of combustion is dissipated before arrival at the chimney and is thus economized. To get the maximum effect of heating, a stove should have as much exposed surface as is possible without diminishing its heating capacity. The relative heating surface needed for any given space warmed by a stove may be approximately determined from data given by Péclet, who found that one square foot of sheet iron, under ordinary conditions, freely exposed to the air, will yield about 200 heat units per hour; a square foot of cast-iron, 500; and bricks or tiles, two-fifths of an inch thick, 180 heat units—supposing the fuel to

be consumed in such a manner as to yield about 80 per cent. of its theoretical heating power.

The materials of which stoves are made are cast-iron, sheet-iron, brick or tiles. When fuel is rapidly burned in a stove, so as to evolve in a short space of time the entire amount of heat it is capable of affording, the temperature produced is often greater than required. Iron, and especially cast-iron, which conducts and radiates heat rapidly, is therefore not an appropriate material for maintaining a uniform temperature—since fires in such stoves require constant attention to maintain regularity of operation. Clay, in the form of brick or tile, is far preferable; since it parts with its heat slowly and gradually, and the surrounding air is maintained at a more even temperature. Hence the best results are obtained by a combination of materials, as an iron fire-box with a lining of fire-brick, by which the stove is enabled to heat up fairly rapidly, yet not give up its heat too fast. This arrangement also prolongs the life of the stove, since when constantly overheated it rapidly deteriorates in character.

With ordinary stoves the amount of direct contamination of the air, which is usually not inconsiderable, depends upon the tightness of their joints, the proper employment of dampers and the avoidance of over-heating. The last, as just explained, may generally be secured by a lining of fire-brick. The production of carbon monoxide and the odors resulting from the scorching of minute atmospheric particles, the vast number of which can be appreciated by watching the path of a sunbeam in a darkened room, are thus avoided. Broken or badly constructed stoves are highly unsanitary and may give off dangerous gases, as carbon monoxide. Badly jointed stove pipes may give out much impurity to air, while the separation of sections of pipe is liable also to result in accidental fires. Base-burner stoves are, by careless soldiers, often damped off to reduce the heat, by closing the valve between the stove and the chimney instead of those which admit air to the fire. In this way the products of combustion are forced into the squad-room under pressure, producing headache, dizziness, languor, loss of appetite, nausea and other symptoms. In some instances, the poisonous gases from improperly damped stoves have been inhaled in sufficient quantity to produce death. Putzeys states that, during the period of 1867–70, there were 170 cases of asphyxiation in the Prussian army from the fumes of burning coal, and that 45 of these terminated in death—as a result of which the use of such dampers was forbidden in that service. While the dampers used in our stoves probably do not fit sufficiently tightly to justify any apprehension of fatal poisoning, their misuse undoubtedly does much to cause contamination of the air and produce toxic symptoms of no little intensity. The manipulation of the stoves in a squad-room should, therefore, be prohibited to all but the room-orderly or the non-commissioned officer in charge of a squad. Stoves have the practical disadvantage of occupying space in the squad-room. They require much attention, particularly in very cold weather and with inferior fuel, and their manipulation is productive of dust, noise and confusion. The fine impalpable powder produced in shaking down the ashes, or in their removal, is irritating to the respiratory tract and interferes with the maintenance of proper cleanliness in the squad-room. Equability of heating for any considerable period is not to be secured with stoves, and usually the fires are allowed to

die down to a considerable extent during the night. Stoves, however, furnish an economical method of heating under circumstances and conditions where central heating is not practicable or is not required. They distribute heat more equably throughout an enclosed space if located at or under the center of the latter; through their chimneys they act as extracting shafts—an additional reason why they should be given a central position. No stove is complete without an evaporating vessel, kept full of water to supply the necessary amount of moisture to the heated air. Ordinary stoves do not contribute to ventilation, except in so far as a comparatively small quantity of air is passed through the fire in the support of combustion. This limited amount of air is drawn from a point close to the floor, and thus there is little movement of air in the upper levels. Since the air required for combustion is taken directly from the room, incoming air-currents are necessarily established—but the drafts are by no means as severe as with open fires. For squad-rooms, it is well to guard its vicinity from an excess of heat by surrounding the stove with a sheet-iron cylinder, extending from the floor to the top of the stove. Fresh air may be admitted under the stove, and is thus heated as it is passed over its surface upward into the room. If, in addition, the stove-pipe be so placed as to warm a flue for the escape of foul air, and an opening be made in the latter near the floor, an excellent arrangement for warming and ventilating the squad-room, equably and without the production of drafts, is thus secured. This plan is illustrated in Fig. 217. No stoves of ordinary construction should be put into a squad-room without being arranged in some such manner.

With the purpose of improving upon the arrangement for combined heating and ventilating, just described, a number of varieties of ventilating stoves, depending on the same general principle, have been devised. These merely consist of an inner fire-box surrounded by an outside metal envelope, which provides for the circulation and warming of air in the intermediate space and reduces the intensity of radiation. It is evident that for true ventilation the air warmed in this intermediate space must be drawn directly in from the outer air. Some so-called ventilating stoves merely heat air already in the room and have no connection with that outside; thus clearly having no value as ventilating agents and possessing no special merit save that of establishing circulating air-currents by which the more equable warming of an apartment is probably secured.

Ventilating stoves are much used in the German army, and have been employed to a considerable extent in our own service. The pattern generally issued is that of the Cortland Howe ventilating stove, which is regarded as the best variety by the Quartermaster's Department. This stove operates very satisfactorily as far as the diffusion of heat is concerned; thermometric tests showing a difference in temperature of only three to five degrees at points just above the floor and below the ceiling, in rooms containing about the cubic space which this stove is guaranteed to heat. With respect to ventilation, the results are not so satisfactory. Tests show that this stove is capable of warming and introducing only about 1,600 cubic feet of air per hour; a quantity which might be considerably increased by a breeze blowing into the cold-air pipe, or which might be somewhat reduced by air-currents from the opposite direction. With two such stoves in a squad-room containing twenty-four men, it is obvious that

the quantity of warmed fresh air introduced would scarcely suffice for the needs of a single individual. As seen by the accompanying illustration, the Cortland Howe stove is provided with a heat-aspiration shaft, opening near the floor. This shaft appears to be able to remove a bulk of foul air equal to that of about four-fifths of the entering fresh air; the remaining quantity being utilized in the combustion of the fuel or passing through the fire to escape by the chimney. This heating apparatus is excellent in theory, and works well in practice so far as its operation goes; but its air-passages are too small and as a ventilating agent it is much over-rated. Further, it has no provision by which the entering air can be supplied with its proper amount of moisture. In determining the size of the intake with ventilating stoves, together with the number of the latter required, Putzeys states that this may be estimated, for a space having a known cubic contents and number of inmates, from the fact that one kilogram of coal burned is capable of raising the temperature of 900 cubic meters of air, moving at the rate of two meters per second, to the extent of 20° C. From the constant supply of warmed fresh air which is drawn in from the outside, the cold drafts caused by stoves of the ordinary pattern are avoided with this model. The apparatus is stated to be gas-tight, and to be incapable of being heated to a red heat. It does not require the combustion of any excessive amount of fuel. This stove, like many other ventilating stoves, is claimed to be a better heater than those of ordinary pattern. This is not the case, for Morin has shown that the latter may be capable of utilizing ninety per cent. of the theoretical heat of combustion. Further, the introduction of volumes of newly heated air, by ventilating stoves, is inseparably connected with the expulsion of an equal volume of foul air, which carries with it a certain amount of heat. Hence it follows that the ordinary stove may actually be more economical as regards heating than the ventilating pattern, though the better distribution of heat by the latter may give the impression of greater warmth.

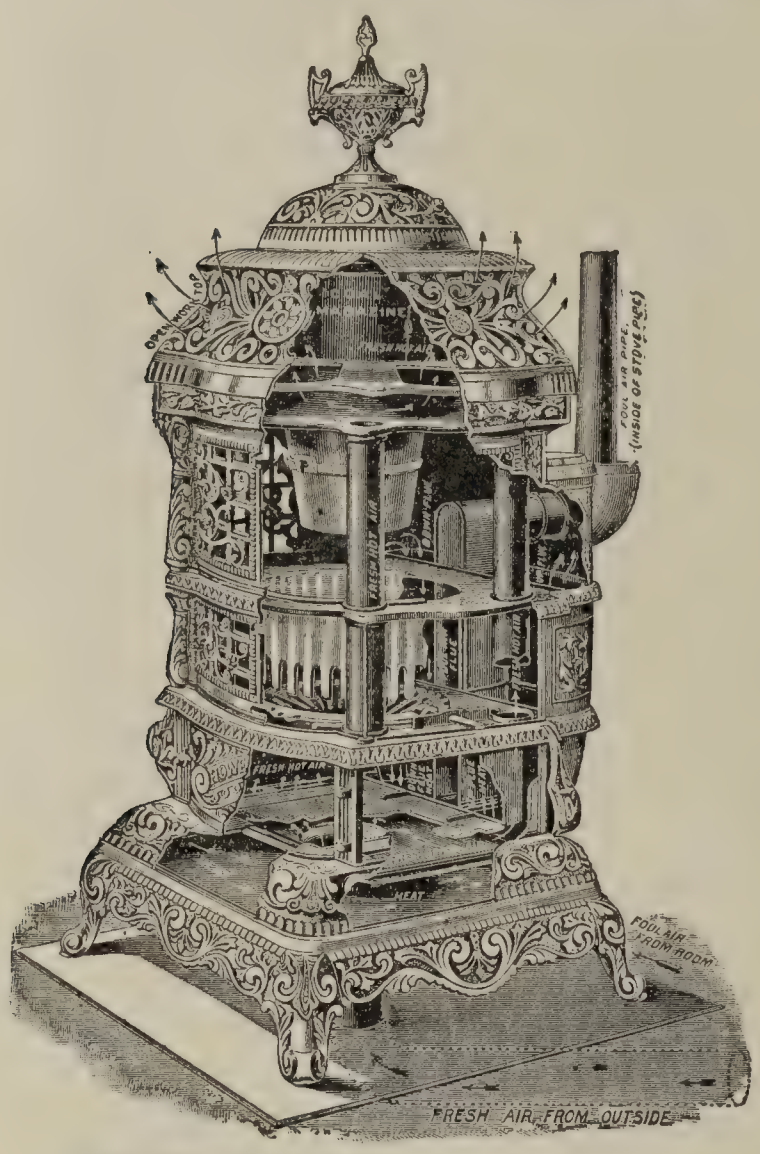


FIG. 242.—Cortland Howe Ventilating Stove.

Chimneys.—It frequently happens that a chimney will smoke vigorously when a fire is first started, especially when it has long been disused. This is generally due to a low temperature of the air in the chimney, and an inability to cause its displacement upward. Such a condition is obviously only temporary and disappears as soon as ascending currents of

hot air are established. If the smoking is continued, it may be that the chimney is clogged with soot; that bricks have been blown in from the chimney-top and thus obstructed the shaft; that descending air-currents have been created by neighboring buildings; or finally, that several chimneys running from the same space, or several connecting spaces, are working against each other. If the chimney is stopped with soot and needs cleaning, the fact may be told by inspection; while a stoppage by bricks is readily detected by sounding from the roof with a line and plummet. The actual location of such a stoppage, if one exists, may be found by an assistant, who listens at the chimney, from several floors, while the plummet is being struck against the obstruction. The latter may be readily located for removal, generally only to be accomplished by tearing a hole in the masonry of the chimney, by the noise produced by the impact. Descending air-currents may be caused by the deflection of wind from neighboring buildings, and may occur even when the latter are at some little distance. They may generally be caused to disappear by building up the chimney several feet higher and protecting its outlet with a suitable upcast ventilating cowl. Where several chimneys work against each other, as in several adjoining rooms having free air communication, the smoking may be caused to cease by destroying this air communication by closing the doors between them. If several flues, from the same room and of equal height, work against each other, either all should be brought together into a single shaft with a suitable cowl, or all but one should be closed.

In this connection, it may be mentioned that stove-pipes and chimneys should be kept free from soot, not only for the better draft which is thus afforded but to limit the liability of the soot catching fire. The frequency of cleaning obviously depends upon the character of the fuel used and the amount burned. With bituminous coal the proportion of soot produced is relatively large. Chimneys are best cleansed, after stopping up all holes for the entrance of stove-pipes with wads of newspaper or gunny-sacks, by going on the roof and letting a loop of chain on the end of a rope dangle down the chimney, moving it up and down so as to scrape it over the sides of the flue and thus dislodge the soot. The latter is then removed from the bottom of the shaft. Stove-pipes are best cleaned by taking the sections carefully apart and removing them to the open air for scraping and brushing. When the soot in a stove-pipe or chimney takes fire, the combustion may be stopped by throwing a handful of sulphur into the stove; the fumes of sulphur dioxide thus produced promptly smothering the flames in the chimney shaft.

Central Heating.

In central heating, air heated in furnaces is distributed through the various spaces to be warmed; or the heat resulting from the combustion of fuel is stored in water or steam under circulation, to be dissipated where required by contact and radiation. Heating by electricity being about fifteen times as expensive as by the use of the methods just mentioned, it obviously need not be considered in connection with the military service. In general, the use of steam gives better results in very cold climates, while

the hot-water systems are more applicable to localities in which the temperature is never excessively low. Under all circumstances, heating by hot-air furnaces may be regarded as less desirable than the methods just mentioned for securing warmth in barracks.

The advantages of central heating plants include an economy in fuel and labor, cleanliness and freedom from dust, the equable distribution of heat throughout an entire building and the possibility of maintaining a more uniform temperature for long periods. The last can be readily secured by the use of automatic thermostats when great variation of the outside temperature does not occur; but, on the whole, the efficiency of a central heating system is dependent to a considerable extent upon intelligent operation. The warming of fresh air required for ventilation is also more satisfactorily performed with central heating plants, and the production of cold drafts is reduced to a minimum. In our service, central heating is employed only in barracks of fairly recent construction or those which have been lately remodeled. Since many slightly different methods of central heating have been applied to barracks in our own and foreign armies, it is impossible here to point out the special defects or advantages of this or that system; and merely general types of the chief systems in common use can be considered.

Heating by Hot Air.—When want of space or other considerations render it desirable to have fires located away from the rooms to be heated, the necessary quantity of air can be warmed in another part of the building and conducted by flues to the desired points. This air is generally heated by the use of the hot-air furnace—a device which is practically nothing but an enlarged pattern of the ventilating stove, being, in its essentials, an air-tight fire-box partially enclosed in an outer envelope; air from outside being drawn into the intermediate space, warmed, passed over a water reservoir and then distributed as required. With respect to the more minor details, hot-air furnaces are constructed according to either of two systems. In one, the smoke and hot gases from the fire are caused to circulate in an extensive system of stone-ware or metallic flues, and the air to be warmed is conducted from the outside of the building to around these flues. In the second system, the conditions are reversed and the air itself is conducted through similar pipes, around which the flame is allowed to play. Although there are a large number of hot-air furnaces on the market, they all, however they may differ in appearance or detail, conform in principle to one of these systems. No special pattern of hot-air furnace is used in our service.

The hot-air furnace being, as just stated, practically a large ventilating stove, it is beset with many of the disadvantages attending that apparatus. It has, however, many positive advantages. The system secures the constant admission of fresh warmed air, and hence ventilation is excellent if an outlet be provided; for volumes of air are thus forced in from outside, in place of the exhaust resulting from combustion in a stove in the room itself. The result is that instead of there being cold air-currents entering through existing cracks and crevices, the constant tendency of the air is to move outward and there are no drafts. The equable heating of buildings is also generally secured with hot-air furnaces; but the distribution of warmth may not be good in high winds, and the rooms on the exposed side of bar-

racks are liable to be cold and cheerless under such conditions. Sometimes fans are used to overcome this defect and secure the equable distribution of the heated air. If the distributing pipes are much bent, the loss of head by friction may be so great as to prevent the proper warming of a room except under very favorable conditions. The flues also accumulate dust, which further operates to retard the passage of air through them. Generally, the warming influence of hot-air furnaces is limited to a radius of thirty-five to forty-five feet; and in a large building the idea of concentration is illusory, if a number of furnaces are required. This method of heating is also not desirable where the number of rooms to be warmed varies, since furnaces of this character are not adapted to meet a fluctuating demand. The entering air also is often scorched by passing over too hot surfaces, and thus may present a bad odor. With such overheating, moreover, the air enters the room at too high a temperature, and there is no way of properly diluting it with fresh cold air. Under these conditions, recourse is usually had to partially or wholly closing the valves of the register, but this destroys ventilation by cutting off the supply of fresh air.

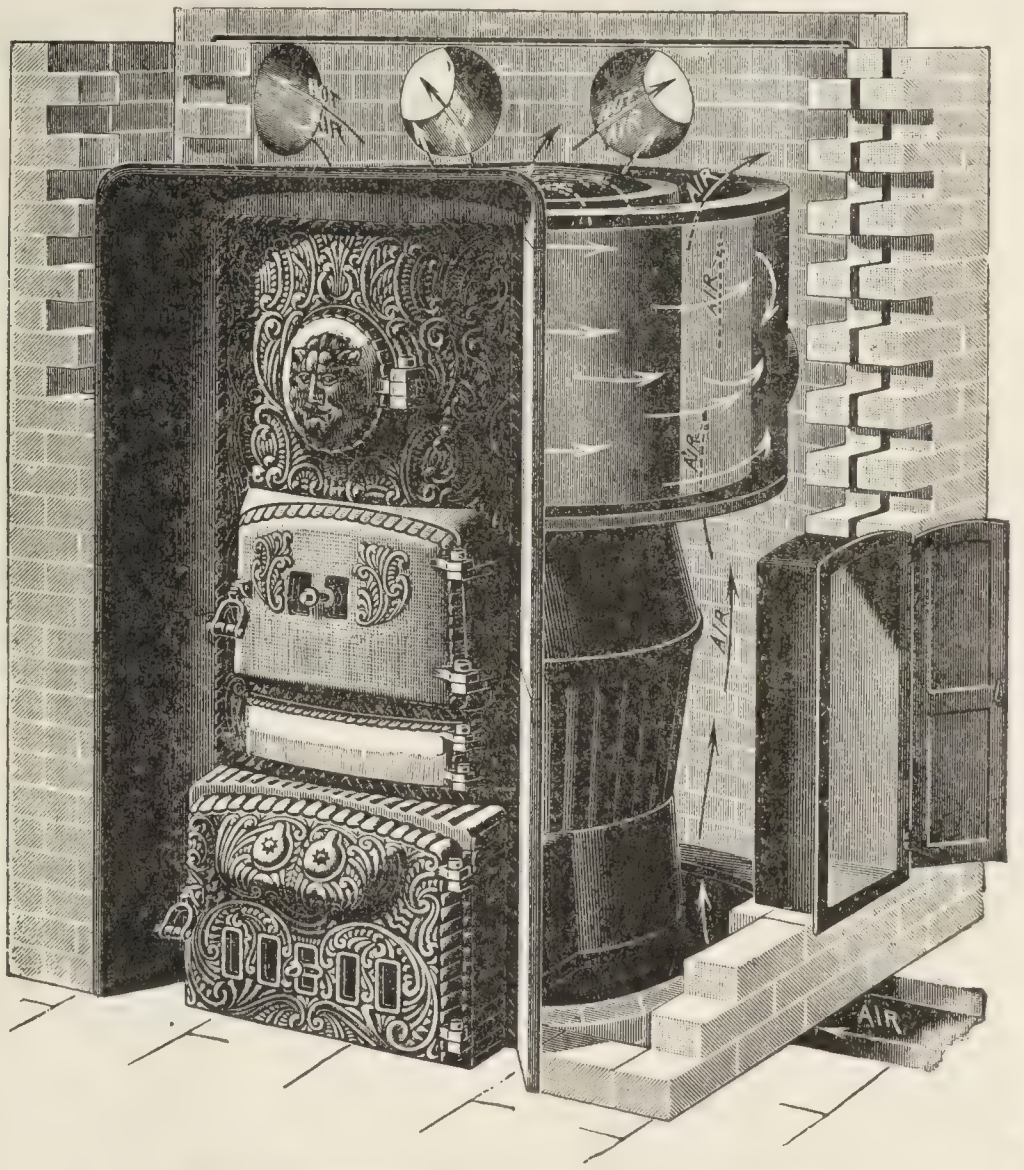


FIG. 243.—Common Pattern of Hot-air Furnace.

Careful attention to details will do much to minimize the faults of the hot-air system. Where strong cold winds prevail from one direction, the furnace should be located near the windward side of the building; for it is said to be as difficult to move the heated air ten feet against a fairly strong wind as forty or fifty feet with it. The furnace and air-shafts should be kept scrupulously clean; the registers in squad-rooms, particularly if in the floor, are liable to accumulate dust and refuse and should be removed at frequent intervals to permit of policing. Great care should be had that all joints are tight in the furnace proper and that the air-heater is entirely disconnected; since otherwise the gases are carried over the entire building. The heat applied to the entering air should not be of too high a degree, but should be sufficiently protracted to give the required temperature. When a furnace will not

warm a building during cold weather without itself becoming over-heated, it is either too small or has too little heating surface in proportion to the fire-pot. Care must be had that the evaporating pans constantly contain water. The air-supply should not be taken from the cellar, even though the latter be apparently clean and free from any contamination with soil-air, but should come from a clean source out of doors, well above the ground level and from the direction of the prevailing winds. The cold-air duct or ducts should be screened at the entrance to prevent the admission of refuse or vermin, should be arranged to permit of regular cleaning, and should have a cross-section equal to eighty per cent. of the combined area of the hot-air flues leading from the furnace. The shaft for cold air should have a damper to regulate the admission of the latter. The use of this damper should be intelligently administered by the soldier in charge and should be frequently inspected; for it not rarely happens that the fact of the damper being wholly or partially closed is overlooked for considerable periods, during which the supply of air is drawn in from the cellar and is often highly impure. It may be desirable to provide for the filtration of the entering air through coarse cloth or fine wire gauze, especially if there be much dust in the incoming air. If possible, the hot-air flues or ducts should not be flat, but round or square, to lessen the friction; and for the same reason they should be as direct in their course and as nearly vertical as possible. They should be covered from the furnace to the register openings with asbestos or other non-conducting material, to prevent the loss of heat from them that otherwise occurs into the cellar and between partitions. Their register openings into the rooms should not face the windows or prevailing winds unless absolutely unavoidable; for if they do, the passage of warm air into the room will often be completely checked. It has been proposed so to construct flue openings as to break the entering hot air into numerous currents, which are directed downward at a steep angle with the floor. The air is thus caused to enter in exactly the opposite way from which it would naturally take, and in its effort to change its direction the heated fresh air is thus more completely mingled with the air of the room and without producing unpleasant drafts.

From what has been said, it is apparent that the hot-air system possesses many defects as regards the heating of barracks, as compared with steam or hot water. It is, however, a decided improvement over heating by stoves. The hot-air system, in our service, has of late been installed only in long-established posts and generally in old buildings. None of the barracks constructed during the past eight years have been heated by this method, but it is still employed in a considerable number of the older posts. At Madison Barracks, a system providing for the propulsion of the heated air by fans has been installed, but generally reliance has been had upon the natural upward movement of the heated air itself.

In installing the hot-air system of heating, or in remodelling existing arrangements which are unsatisfactory, the size of the heater and of the air shafts required should be known in advance. Calculations as to the size of registers and hot-air pipes to be used are frequently unsatisfactory, and reliance is usually had, in this country, upon dimensions which have

been found by experience to be sufficient under certain conditions of climate. For the climate of Chicago and the northern part of this country, the subjoined table is generally followed; it being assumed that all hot-air flues are placed in interior walls.

Cubic feet of air that can be kept properly heated in rooms having one side exposed.	Total size of register to be used.	Hot-air capacity of register used, in square inches.	Hot-Air Pipe to be Used.	
			Size, inches.	Capacity in square inches.
1,600	8 × 10	53	8	50
1,800	9 × 12	72	9	64
2,200	10 × 12	80	10	78
2,300	10 × 14	93	10	78
2,700	12 × 14	102	12	113
3,500	12 × 15	120	12	113
4,500	12 × 19	152	13	133
5,500	14 × 22	205	14	154
6,500	16 × 20	214	16	201
8,000	20 × 20	267	18	254
11,000	20 × 26	347	20	314
14,500	24 × 27	432	22	380
20,000	27 × 27	486	24	452
25,000	30 × 30	600	28	616
30,000	27 × 38	684	29	661
40,000	30 × 42	840	31	755

For the climatic conditions found in New York city and points south of the same, the following table is usually employed:

Cubic feet of air that can be kept properly heated in rooms having one side exposed.	Total size of register to be used.	Hot-air capacity of register, in square inches.	Size of Hot-Air Pipe to be Used and Capacity of Same.	
			Size in inches.	Capacity in square inches.
1,300	8 × 10	40	8	50
1,800	8 × 12	53	8	50
2,250	9 × 14	72	9	63
2,800	10 × 14	93	10	78
4,400	12 × 15	120	12	113
6,100	12 × 9	152	13	136
8,000	14 × 22	205	14	154
10,800	16 × 24	256	16	201
14,700	20 × 20	267	18	254
22,000	20 × 24	320	20	314
26,000	21 × 29	406	21	352
31,000	24 × 24	384	22	380
34,000	27 × 27	486	24	452
44,000	30 × 30	600	28	616
50,000	30 × 36	720	30	707

With regard to the heating power of furnaces, the following table is based upon the climatic conditions found in New York city and points to the south. For colder localities the number of rooms which can be heated, as given below, must be decreased. Usually an allowance of fifteen to twenty per cent. is made in this respect.

Furnaces.	Heating capacity.	Estimated size of air, boxes from west, northwest, or north.
36-inch cases.....	6 rooms 14 × 14 each.	12 × 24 inches.
40 " "	7 " " " " "	12 × 28 "
44 " "	8 " " " " "	12 × 32 "
47 " "	9 " " " " "	12 × 35 "
50 " "	10 " " " " "	14 × 34 "
55 " "	12 " " " " "	14 × 40 "
60 " "	14 " " " " "	14 × 47 "
66 " "	16 " " " " "	14 × 54 "

Heating by Hot Water.—By reason of the high specific heat of water, the latter serves excellently for the storage and transportation of heat and its distribution where required. The quantities of heat contained in equal weights of water and air at the same temperature are in the ratio of 421 to 100; or the heat which is set free when water cools down one hundred degrees is sufficient to raise the temperature of 4.21 times its weight of air to the same amount. But for the same weight, air occupies 775 times the space that water does, and hence one cubic foot of water, losing one degree of heat, is theoretically capable of raising the temperature of 3,250 cubic feet of air by one degree; but in practice a small deduction is usually made for warming the moisture present in the air, and it is generally assumed that a given volume of water, in cooling a definite number of degrees, will raise the temperature of 3,000 times its own bulk of air to the same extent. It is evident, therefore, that a small quantity of heated water is capable of warming a relatively enormous volume of air.

Heating by hot water is conducted by either the low-pressure or high-pressure system. With water at low pressure, the distributing pipes are so arranged as to form a loop through which the water circulates. Usually the piping employed is about four inches in diameter. The boiler in connection with this piping is commonly placed in the basement of the building, and from its upper part runs a main pipe, dividing into lateral branches which may extend to the furthermost parts of the building. These lateral branches, at their terminations, are expanded into radiators so as to promote the dissipation of the conveyed heat. A return pipe runs from the bottom of each radiator, and passes back, underneath the distributing pipe, to discharge its cooled water into the boiler at its lowest part. The circulation is open to the air at its highest point, where the main distributing pipe opens into a tank which provides for any expansion and permits the escape of air; while a valve at the lower part of the system automatically admits cold water to replace any losses as they occur. The operation of the system depends upon the fact that water on being heated becomes of lesser density than when cold, and thus tends to seek a higher level. Having given up its heat to the various rooms and become heavier, it is passed on to return to the boiler, which is the lowest part of the system, to be reheated. A continuous circulation is thus ensured, the motive power being gravity. The circulation being open to the air at one point, the highest temperature possible at or near the top, where this opening is, does not exceed 212° F. At the deeper portions it may be higher; but the average temperature in the distributing circulation rarely exceeds this point. For

both the distributing and return pipes the average temperature is generally estimated at about 140° F.

The calculation of the flow of water in the circulation is very similar to that of air, the head being due to difference in the densities of hot and cold water. To find the head for any circulation, the latter may be conveniently divided into foot-sections by horizontal parallel planes one foot apart. By measuring the temperature in the flow and return pipes of each section, the head of the whole circulation will be the sum of the differences of temperature of corresponding sections, multiplied by the coefficient of expansion of water. The average temperature in the flow and return pipes will be between 92° and 212° F. and for this range the mean coefficient of expansion of water is given as 0.000318; hence the head for each foot-section $= 0.000318\ (t-t')$. However small the head may be, there will be a flow of some sort, provided there is a continuous channel filled with water from the boiler and back again. The precise velocity depends not only on the head but also the resistance. Its computation is subject to the same laws as those governing resistance in air channels; but, as such calculation is very intricate, most engineers work empirically from known successful arrangements.

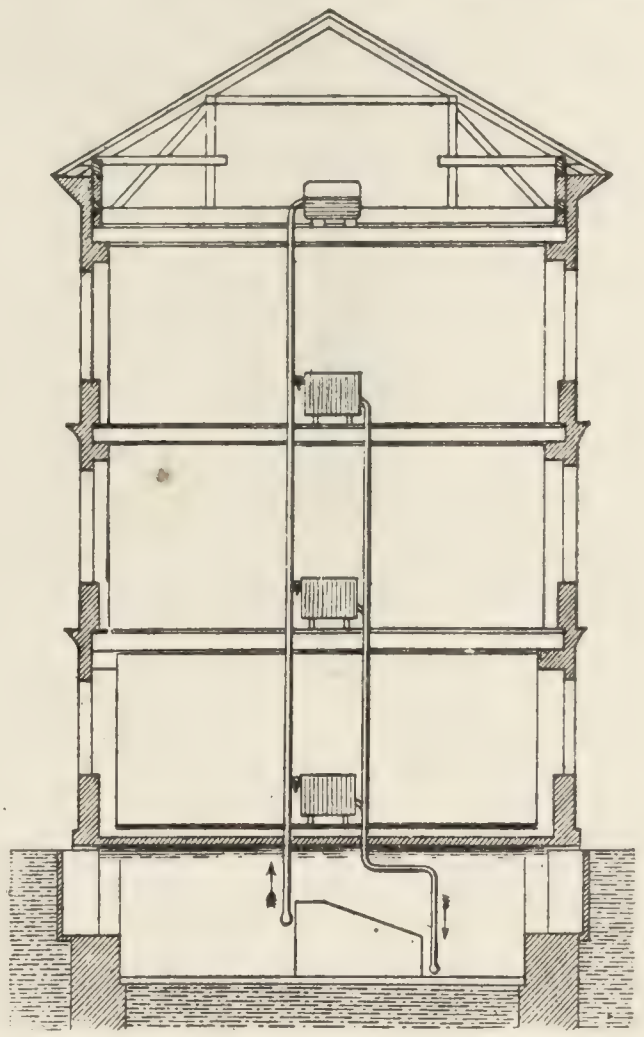


FIG. 244.—Diagram of Low-Pressure Hot-Water System.

The system of heating by hot water under low pressure operates with great regularity. Since water possesses a high specific heat it does not cool down rapidly, and where equable and continuous heat is required this method of warming possesses many advantages. By this system, the heating begins when the fire is lighted and gradually increases in degree, continuing for hours after the fire is out and until the water is cold. The heat in any of the radiators can be controlled by opening or closing its valve, without affecting the operation of the remainder of the system. The temperature of the various rooms can thus be regulated as desired; while the heating, as a whole, is controlled by the intensity of the fire, enabling much or little heat to be obtained as required by variation in the external temperature. Other advantages of the low-pressure system are found in the fact that the temperature of air coming in contact with the heaters cannot be unduly elevated and thus scorching of the atmospheric particles is avoided. Ventilation is readily secured with this system, which obviously can in itself in no way impair the quality of the air. The apparatus required is simple, is noiseless in operation, easy of manipulation and can be run at comparatively low cost. Since it is provided with an open expansion tank, the production of steam is avoided and the system is free from the danger of explosion. During periods of

disuse during cold weather, however, it is important that the water contained in the apparatus be drawn off, to avoid the possibility of freezing and the resulting broken pipes. An objection to the use of this system in places which are intermittently heated, as drill halls or gymnasia, is found in the time required properly to heat the considerable bulk of water employed.

A question of very practical importance is how much hot-water piping, of a given external diameter, is necessary for the heating of a given room. The answer to this depends upon a large number of conditions, more especially as to the loss of heat through the walls and windows as well as that carried out by the air in process of ventilation. Much of present information on this matter is due to Hood, who says that an iron pipe four inches in external diameter loses 0.851 of a degree of heat Fahrenheit when the excess of its temperature is 125° F. above that of the surrounding air. He estimates also that one foot of a four-inch pipe will heat 222 cubic feet of air 1° F. per minute, when the difference between the temperatures of the air and the pipe is 125° F. The following table, from Hood, shows the length of four-inch pipe at 200° F. necessary to warm 1,000 cubic feet of air at varying internal and external temperatures. If the diameter of the pipe is increased in any ratio, the length required will be reduced in the same ratio. Thus 100 feet of four-inch pipe can be replaced by four-thirds of 100 feet, or 133 feet, of three-inch pipe, and so on.

Temperature of external air.	Temperature, in Degrees Fahrenheit, at which the Room is Required to be Kept.					
	50°.	55°.	60°.	65°.	70°.	75°.
10° F.....	150	174	200	229	259	292
12	142	166	192	220	251	283
14	135	159	184	212	242	274
16	127	151	176	204	233	265
18	120	143	168	195	225	256
20	112	135	160	187	216	247
22	105	128	152	179	207	238
24	97	120	144	170	199	229
26	90	112	136	162	190	220
28	82	104	128	154	181	211
30	75	97	120	145	173	202
32	67	89	112	137	164	193
34	60	81	104	129	155	184
36	52	73	96	120	147	175
38	45	66	88	112	138	166
40	37	58	80	104	129	157
42	30	50	72	95	121	148
44	22	42	64	87	112	139
46	15	34	56	79	103	130
48	7	27	48	70	95	121
50	....	19	40	62	86	112

To obtain the amount of radiating surface required for a given room and to compensate for heat lost from walls, windows and doors, Baldwin gives the following rule: Take the difference in temperature in degrees Fahrenheit between the lowest outside temperature to be provided for and the temperature at which the room is to be kept, and divide it by the difference in degrees Fahrenheit between the temperature of the pipes and the temperature at which the room is to be kept. Multiply the quotient thus

obtained by the number of square feet of glass plus the number of square yards of external wall surface in the room, and the product will be the number of square feet of radiating surface required. This calculation does not provide for any leakage of air through crevices or for any change of air by ventilation. To allow for this, the additional calculation is made of multiplying the number of cubic feet of air admitted per hour by the number of degrees Fahrenheit which they are to be heated, the product being divided by 12,500. The quotient is the number of square feet of radiating surface required to allow for ventilation; and this should be added to the number of square feet of radiating surface, as calculated above, for a room without such ventilation. In practice, empirical rules as to the size of the radiators, varying with the locality, are generally followed and give excellent results. A very satisfactory rule much used for determining the number of square feet of radiating surface necessary to warm a given space consists in multiplying together its three dimensions of length, breadth and height, expressed in feet, and dividing the product by a divisor varying from 25 to 30, according to the locality. The result gives the amount of radiating surface required. Usually the number 25 is employed as the divisor where cold climates or exposed rooms are concerned. By many, also, the last named number is used under all circumstances; they preferring to regulate the heat by manipulation of the fire, and to thus have a sufficient radiating surface to meet the emergencies of very cold weather without the necessity of maintaining an unduly hot fire in the heater.

Radiators, whether for hot water or steam, may be of many forms, vertical or horizontal, and composed merely of a series of large condensing pipes or of the more elaborate special arrangements commonly employed. They are best placed immediately under the windows of the squad-room and covering the openings for the admission of outside air. The cold air thus admitted passes up between the pipes of the radiator and is warmed before escaping into the room. The details of this method are shown in Fig. 216. Another advantage of locating the radiators below the windows is seen in the fact that descending currents of air, chilled by contact with the windows, are thus warmed and their unpleasant action is neutralized. Sometimes radiators are located in the middle of the squad-room. This is a bad arrangement, since the room is much less equably heated, considerable space is lost for administrative purposes and the entering air passing in through registers beneath them must traverse long shafts—necessarily containing at least one right angle and certain from the nature of things to become and remain foul from the deposition of dust. When placed against the wall, however, the radiator is less readily got at from all sides and careful inspection will often reveal behind them unsanitary accumulations, the existence of which had not been suspected. This is particularly a fault of the direct-indirect apparatus as used in our service, since this radiator is built up solidly from the floor, and is especially hard to keep clean. The air-box of the radiator requires to be inspected at least once a month, and the top gratings should be frequently removed for purposes of cleanliness.

There are a large number of patterns of low-pressure water-boilers, but the best are those in which the water is caused to circulate in small pipes so distributed as to make the most of all available heat. The accompany-

ing cut of the "Perfect" boiler shows the great amount of heating surface exposed to the direct action of the fire. In this apparatus, the water, in the process of heating, circulates twice around the fire-pot, then enters the first water section, passing across this section into and across the next water section, and so on, crossing and recrossing the rising column of heat; the bottom of the V-shaped channels being nearest the fire, the small body of water circulating therein absorbs heat and expands and rises up where the channels are larger, thus maintaining a positive circulation with the minimum of friction. In this heater, every particle of water is compelled to travel around and over the fire seven times before reaching the mains, thus absorbing the greatest possible amount of heat from the flame and gases in their course from the fire-box to the smoke-flue. Owing to their peculiar construction and the small body of water contained in each section, a positive and rapid circulation is caused through every part of the heater which prevents the accumulation of sediment and makes it a very powerful circulator. The fire-box of this heater holds sufficient fuel to last from eight to twelve hours, thus requiring but little attention.

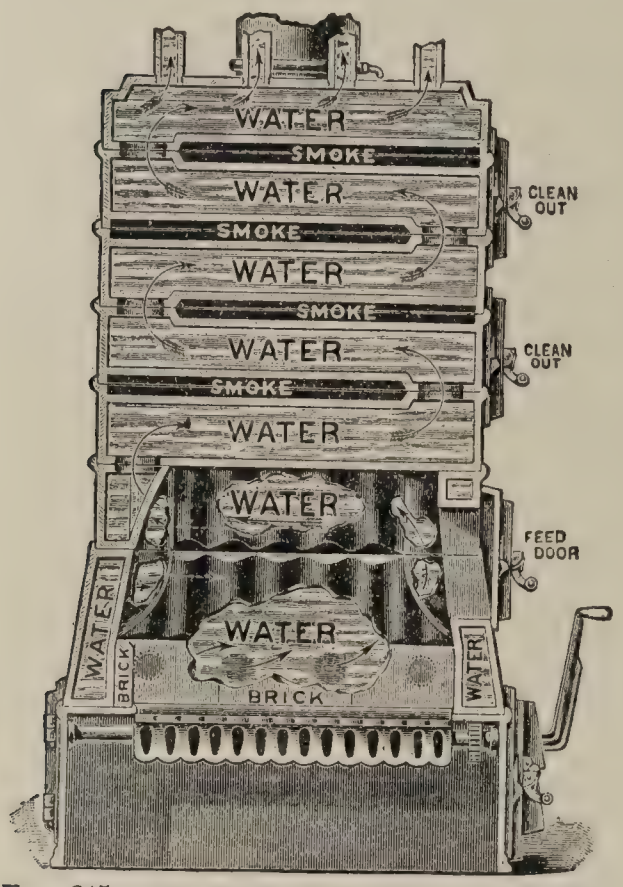


FIG. 245.—Side View of Boiler, Showing Circulation of Water and Amount of Water Surface Exposed to the Heat.

The low-pressure system of hot-water heating is used to a considerable extent in our service. It is much used for the warming of officers' quarters and is commonly put into barracks at all but the coldest stations. For hospitals, it is the method of heating generally employed. The system is regarded by the Quartermaster's Department as being much safer and less liable to accident than is the high-pressure system, and hence, where hot-water heating is to be used, it is the method which is commonly selected.

A combination hot-air furnace and hot-water system has been employed to some extent in civil life. In such a system the water-heating surface is obtained by inserting a coil of pipe in a hot-air furnace, and certain rooms are thus warmed by the hot air while others are warmed by hot water. This system is theoretically excellent for certain conditions, but practically it is difficult to design and construct in such a manner that the supply of heat to different rooms shall be positive and well distributed. The arrangement has no special applicability to the military service.

In the high-pressure system the water is completely enclosed in wrought-iron pipes, whose internal diameter is usually $\frac{7}{8}$ inch and external diameter $1\frac{5}{16}$ inches and which are sufficiently strong to withstand the pressure corresponding to very high temperatures. Thus the pressure required to prevent steam from forming at 212° F. is $14\frac{3}{4}$ pounds per square inch; at 300° F. it is 67 pounds and at 400° F. it is 250 pounds per square inch. The small iron pipes are so arranged as to

form a complete circuit, as in the low-pressure system; part of it being coiled within and exposed to the heat of a fire. At the top of the circuit there are one or more larger pipes called expansion tubes. These contain half air and half water, and therefore allow for the expansion of the latter without explosion. When the pipes have been filled with water they are closed with screw plugs; making the whole circuit practically a closed vessel full of water except at the top, where there is an air space amounting to 15 to 20 per cent. of the total capacity of the pipes. The temperature is regulated by the amount of pipe within the fire as compared with that without it—the proportion varying from 1 : 16 to 1 : 10 according to circumstances. The temperature also depends upon the height of the fire itself. Once started, the circulation of hot water within these high-pressure pipes is very rapid. The water is heated much above the normal boiling-point and the system is usually operated at a temperature of 300° F., though sometimes greater pressures are employed.

With the high-pressure system, the quantity of water contained in the circulation pipes is very much smaller than with the low-pressure system, and hence it can be raised to a heating temperature in a much shorter time. This period of preliminary heating is said to be only one-sixth of the time required for the production of steam. On the other hand, there is no such reserve of heat as with the low-pressure system and the water cools down rapidly as soon as the fire is extinguished. The system is easily installed, easy of operation and economical of fuel. One of its faults consists in the irregularity of temperature found in different parts of the same loop of piping, and there is some difficulty in regulating it according to the needs of the moment. High-pressure pipes are also liable to over-heat the air and may be a cause of accidental fires. Putzeys states that wood is carbonized at a temperature of 257° F., and is capable of combustion at 343° F. Hence it is desirable that these pipes should be isolated from all inflammable substances. As with stoves and furnaces, the odor of scorching from contact of atmospheric particles with an over-heated surface is present with this system. This occurs where the heated surface has a temperature of 285° F. or above. The high-pressure system has, in the past, led to some very disastrous explosions; at present the pipes are usually tested for one hundred atmospheres, although in practice the pressure rarely exceeds six atmospheres. Since, in addition, there are often automatic valves connected with the expansion tubes, it would seem that this apparatus should be quite safe and explosions no longer liable to occur. As with the low-pressure system, if the water is left in the

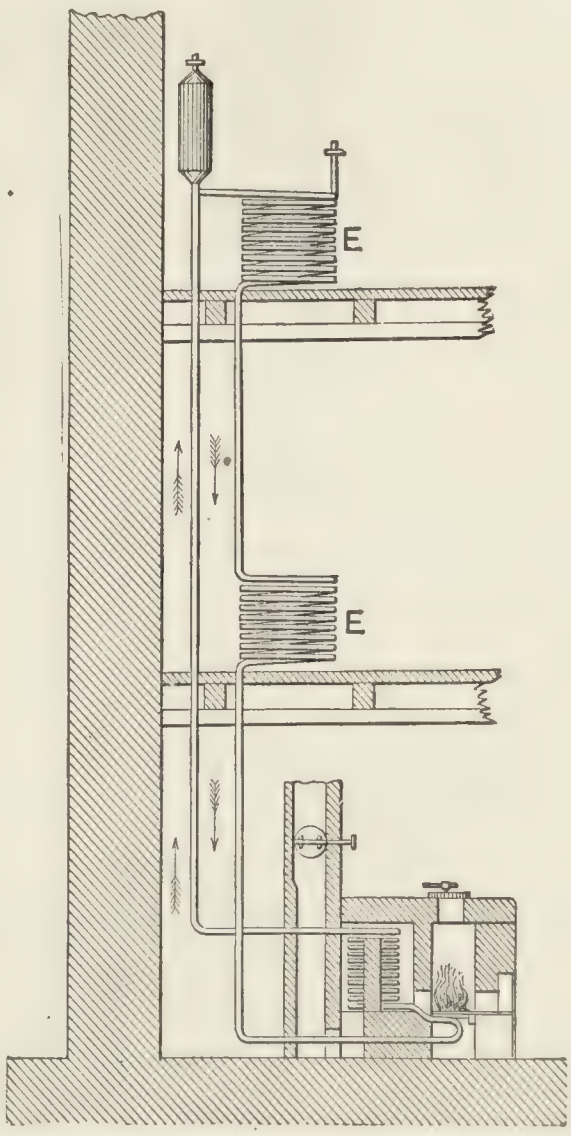


FIG. 246.—Diagram of High-Pressure Hot-Water System.

pipes in unheated buildings, during cold weather, it is liable to freeze. This may be avoided, if necessary, by the use of a solution of calcium chloride in the pipes. In spite of the fact that the water is in a closed system, a certain amount of wastage occurs which necessitates the periodical addition of a fresh supply.

Where the high-pressure system is employed, the necessary area of radiating surface is much reduced when compared with the low-pressure system, through the higher temperature which is reached in the former. The length of the pipe required for radiation can usually be found from the formula $\frac{2.252\ d\ (t'-t)}{D\ (T-t')} = L$, in which d is the number of cubic feet of air to be warmed per minute, t' is the temperature to be maintained in the room, t is the lowest temperature of the outer air to be provided for, D is the known external diameter of the pipe, T the temperature of the pipe and L the length of the pipe required.

Water heating is sometimes accomplished at a temperature intermediate between those of the low-pressure and high-pressure systems. A pressure

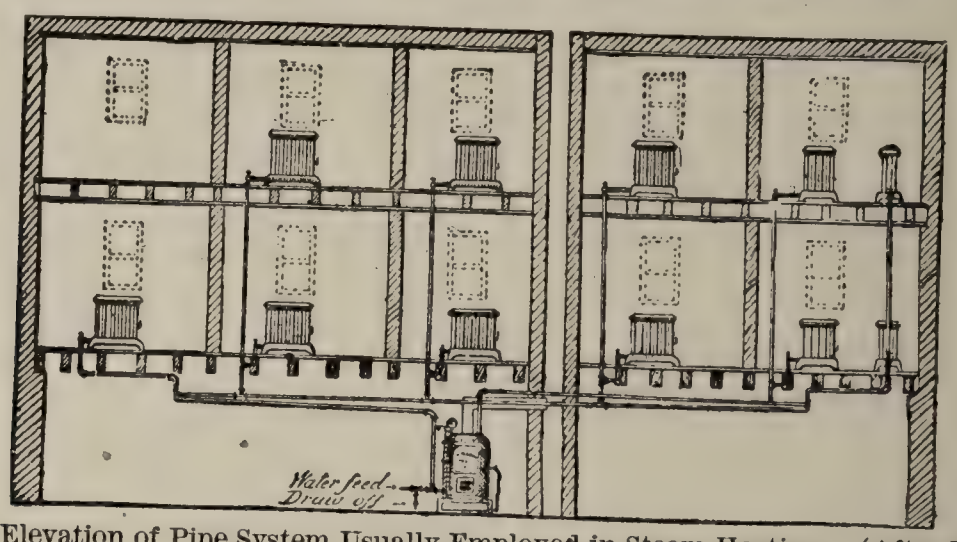


FIG. 247.—Elevation of Pipe System Usually Employed in Steam-Heating. (After Baldwin.)

not exceeding two or three atmospheres is used, corresponding to about 265° F. When this pressure is exceeded, it is automatically relieved by a valve; the diminished pressure operating another valve by which the proper amount of cold water is admitted into the system.

Heating by Steam.—As water is a much better agent than air for the absorption and transmission of heat, so is steam superior to water for the same purpose, since the amount of heat maintained by it in a latent condition is very great. One pound of steam at 212° F. will, in condensing to form boiling water, give off sufficient heat to raise the temperature of 5.36 pounds of water or 22.5 pounds of air to 212° F.

In its essentials the steam-heating system comprises a steam generator or boiler, pipes for the distribution of the steam, condensers in which it may return to water and give up its heat, and finally, pipes for the return to the boiler of the water of condensation. The operation of the system depends upon the fact that steam travels through a closed system over great distances with great rapidity, and without condensation provided the pipes are of sufficient calibre and are properly insulated. The return to the boiler of the water produced by its condensation is accomplished by gravity.

The pipes carrying the steam to its destination are of smaller bore than

are used with the low-pressure hot-water system, usually having an internal diameter of about 1.5 inches. If the building to be heated is large, however, and the steam is to be conducted a considerable distance, the interior diameter of the distributing pipes must be proportionately increased. Thus at Washington Barracks the heating system in one of the barrack buildings was a failure during very cold weather, since the distributing pipes were too small and condensation of the steam occurred before it reached certain of the rooms which it was intended to warm. In addition to ensuring that the distributing pipes are of sufficiently large bore, they should be insulated as much as possible during their course by wrappings of felt or asbestos cloth. For the latter purpose the Ambler asbestos air-cell covering is excellent. The covering is composed of divided air-cells, each independent of the other, produced by arranging in alternate layers sheets of plain and corrugated asbestos paper, wound into cylinders of proper diameter. These cylinders are split longitudinally so that they can be easily slipped over the pipes. The covering is light, neat, nonconducting, fireproof and not liable to deterioration. The radiating pipes are made of at least four times the diameter of the conducting pipes, so as to ensure efficient condensation; and if of copper or cast iron, and colored some dark tint, they radiate heat more rapidly. Since in steam-heating the pressure is usually not more than $1\frac{1}{2}$ atmospheres, the pipes need not be as substantial as with high-pressure hot-water heating. Multitubular steam boilers merit preference over more simple types; since, independent of the security they give, they permit of much greater rapidity in the production of steam than with other boilers. In the United States, to provide for all emergencies, it is customary to allow one square foot of heating surface in the boiler to five feet of radiating surface. Aside from its use for heating purposes, in foreign barracks the steam-heating system, when in operation, is generally utilized to supply hot water for the lavatory and laundry. In the German army, nearly all the cooking of the ration is done by means of steam from this source.

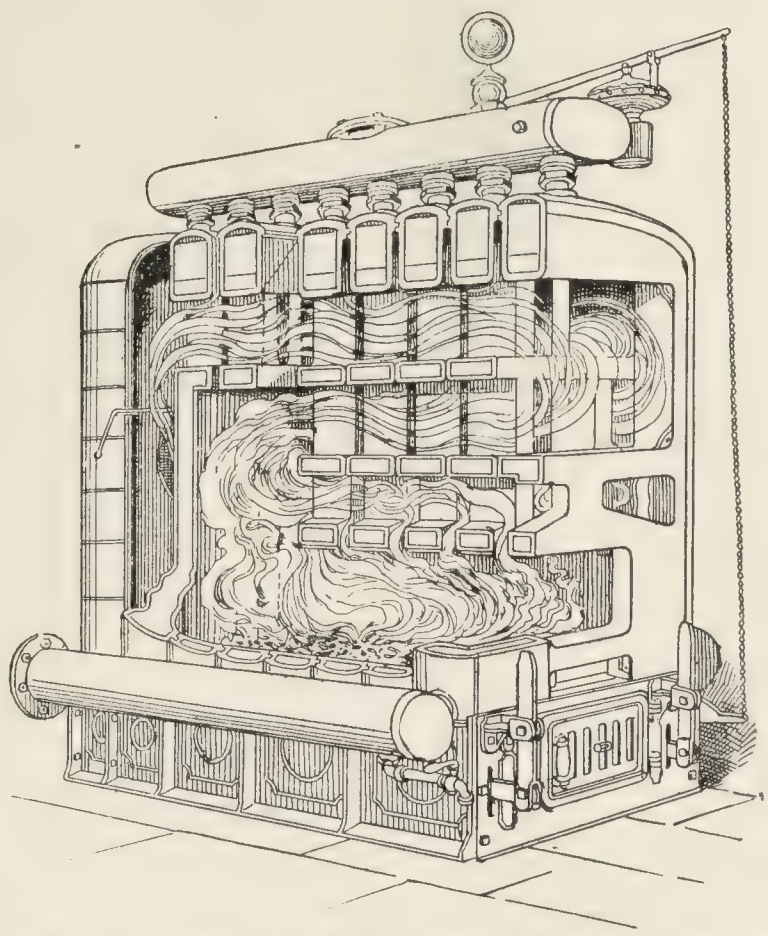


FIG. 248.—Section of Boiler for Steam-Heating, Showing Amount of Water Surface Exposed to the Heat.

The size of steam radiators is obviously dependent upon the amount of heat required. A number of elaborate methods for calculation of the amount of radiating surface necessary have been proposed, but the results given by these are, in practice, no more satisfactory than the common rules of thumb, based on long experience, which are used by steam-fitters. For the United States at large, to heat to 70° Fahrenheit with an outside temperature of zero Fahrenheit, the general rule is to allow one square foot of

radiating surface to each 75 cubic feet of space. Another rule is to allow one square foot of radiating surface to each 100 cubic feet of space, with an increase of radiating surface as follows: Ten per cent. when the exposure is a northerly one; ten per cent. when the building is heated during the day only, the location not being particularly exposed; thirty per cent. when the building is heated during the day only, and the location is an exposed one; fifty per cent. when the building is heated intermittently, with intervals of days or weeks of non-heating. For the climate of Washington city, a common rule is to divide the cubic capacity of the room to be heated by the number 80; corrections for special exposure being made as above. For cold climates, Mills gives the following rule: Allow one square foot of radiating surface for each two square feet of glass, one for each twenty square feet of exposed wall and one for each two hundred cubic feet of space. The sum gives the number of square feet of radiating surface required. Another rule for indirect heating, to maintain a temperature of 70° F. inside with an outside temperature of zero, the surface of the steam radiator being taken at 212° F., is to add the number of square feet of glass to one-fourth the exposed wall surface in square feet, multiplying the sum by the factor 0.7. The result gives the number of square feet of radiating surface required. Clearly there is no one rule which would apply to all cases of building construction and all exposures, and hence considerable dependence must be had upon judgment and the results of experience. One great advantage possessed by steam-heating in this connection is that miscalculation in the size of radiators and pipes, if not excessive, can be overcome by increasing the pressure of the steam.

Steam-heating is now used in a large proportion of the barracks which have been erected during the past decade, particularly those located at the colder stations. It is also much used in foreign services; more especially for hospitals, but also to some extent for barracks. When steam-heating is used there is no direct contamination of the air, but in a close apartment the indirect contamination, from failure to remove the respiratory impurities, is serious—the same air being warmed and breathed over and over again. Hence special means of ventilation, as with hot-water heating, must be provided. This is usually accomplished by the direct-indirect method, which gives most satisfactory results. With steam heat the air is not scorched, since the floating particles are not heated above 220° –225° F., the conduits and radiators are small and the heat is readily controlled by manipulation of the fire or of the radiator valves. The system is devoid of danger, since a pressure of one and one-half atmospheres, corresponding to a temperature of about 235° F., is rarely exceeded. While in operation, steam-heating gives a uniform temperature. There is, however, no reserve of heat, and when the fire is lowered the heater ceases to act and the apartments cool down rapidly. To avoid this, at the military hospital at Vincennes, in France, a system has been installed which includes large tanks of water under the floor, through which steam pipes are made to pass. These raise the temperature of the water, which thus becomes a reservoir of heat. After passing through the water the steam is conducted into condensing pipes, whence it returns to the heater.

A defect which may be present in a badly arranged steam-heating system consists in the violent pounding sometimes noticed in the pipes.

This is due to water accumulating to such an extent as to condense some of the steam in the pipe; thus forming a vacuum which is filled by a very violent rush of steam and water, the latter striking the side of the pipe or radiator with great force. In general, this may be prevented by arranging the piping in such a manner that the water of condensation will immediately drain out of the radiators and pipes and return to the boiler. The common system of steam-heating provides a special set of return pipes for this purpose. As steam diffuses slowly and does not condense rapidly in a space occupied by air, it is necessary to let the latter escape from the pipes and radiators at the time the steam is turned on. This may be done by hand, but is best accomplished by valves of composition metal which are open at ordinary temperatures and close by expansion at the temperature of steam. These again open and admit air automatically if the fire is allowed to die down.

II.

LIGHTING.

In addition to an abundant and constant supply of pure air, the entrance of sunlight into barracks is a matter of much sanitary importance. This can be secured by a proper architectural plan and orientation of the building, a sufficiency in number and size of windows and doors, and by locating the building in such a manner that its sunlight will not be interfered with by trees, buildings or other objects. Porches of too great depth may be a cause of undue shade, and an insufficiency of light is favored if these are painted in somber colors. For the inside of porches and barracks the best results, all things being considered, is given by painting in light yellows or cream color. Pure white absorbs luminous rays least, but it also shows defacement readily and gives rise to a trying glare in direct sunlight. An abundance of natural light in barracks, aside from its obvious necessity for the proper performance of administrative functions, exerts a marked influence upon the efficiency of the sanitary police. Dark, illy ventilated recesses are especially liable to shelter unsightly and unsanitary accumulations, which would never be allowed to exist were they exposed to ready inspection; while even with the best intentions minor sanitary faults are easily overlooked under such conditions. Light, also, particularly direct sunlight, is unfavorable to the growth of pathogenic micro-organisms, none of which can long survive exposure to the solar rays; and the free access of an abundance of natural light into barracks should be regarded as essential to their healthfulness. Deficient sunlight also unfavorably influences physical development and undoubtedly is a factor in the production of mental depression. In many of our older barracks, and necessarily so with casemates, these matters have been disregarded; but in the newer barracks natural lighting has received satisfactory consideration.

In determining the number of windows required for the proper natural lighting of barracks, the number of days of sunshine which may annually be expected in a post should receive consideration; and in cold climates the window area must not be made too large. Putzeys believes that, for temperate climates, it will suffice if the window area is equal to one-sixth or one-fifth of the floor space—or one square yard for each thirty cubic yards

capacity. Trelat goes further, and believes that the window area should equal one-fourth the floor space, or should be calculated on a basis of fifteen square feet per man. It is obviously desirable, in temperate climates, that direct sunshine should reach all parts of a squad-room. Even if windows be made ten feet high, the solar rays cannot strike the floor, if entering at the desirable angle of 35 °–40°, for more than half the width of a squad-room twenty-five feet wide. Hence windows on both sides of a squad-room are necessary to the accomplishment of this end. The amount of light which can pass through such windows depends to a considerable extent upon the quality and character of the glass. Galton showed that ordinary window-glass intercepted thirteen per cent. of light, ground glass thirty per cent., and heavy corrugated glass fifty-three per cent. Dust appears to adhere less readily to glass of good quality and smooth finish.

With respect to artificial lighting, that of our posts and barracks is a matter of much importance; of posts, not only because such lighting is a general convenience but particularly since it is a potent meansof restraining the perpetration of nuisances in the vicinity of barracks—such being especially liable to be committed under cover of darkness. The number of lanterns and street lamps for the illumination of a post, outside of barracks, is fixed by the department commander.

In buildings used as habitations the heat and atmospheric vitiation resulting from artificial lighting are worthy of careful sanitary consideration. This matter has received little attention in our service, and lighting is still accomplished in nearly all barracks and hospitals by the most primitive methods, such as have long since been discarded in nearly all large institutions in civil life. In the matter of lighting, our soldiers are by no means as well treated as are the inmates of asylums and prisons. Candles are supplied as one of the components of the ration, but are rarely used except in the field. Coal-oil is used for illuminating purposes in nearly all garrisons; but at a few posts, near large cities, connection has been made with the municipal gas mains. In several of the new artillery stations, in which electric plants had already been installed for other purposes, electric lighting has lately been authorized in the barracks now under construction.

Unit of Light.—In this country and England, the unit adopted for the measurement and comparison of lights is a sperm candle of the size known as "sixes," burning eight grams per hour and giving out a light known as "one-candle power." Such a candle, on analysis, contains:

Carbon	80 per cent.
Hydrogen	13 "
Oxygen	6 "

and in combustion yields equal volumes of carbonic acid and watery vapor to the air, namely, 0.41 cubic foot. The French unit of light is the Carcel burner, which equals 9.3 standard English candles.

Mineral Oil.—Although various kinds of oil have been employed for illuminating purposes, mineral oil, owing to its cheapness and high illuminating value, is the only one used in the military service. Analyses of this oil, according to Notter and Firth, give the following average composition:

Carbon	86 per cent.
Hydrogen	14 "

When burned in the better kind of lamps, the average consumption of this oil, per candle power, is four grams per hour, giving off at the same time 0.28 cubic foot of watery vapor. With inferior lamps the consumption of oil is often double this amount, accompanied by the production of 0.5 cubic foot of carbon dioxide and the consumption of the oxygen of about 3.2 cubic feet of air.

In our military service, for stations where mineral oil is used, an excellent Rochester-burner lamp of 55 candle-power is issued. One of these burners is allowed to each ten men, or greater fraction thereof, and an allowance of four ounces of oil is authorized for each hour during which the light may be maintained; a matter regulated by the commanding officer of the post with the approval of the department commander. The above allowance does not represent the maximum burning power of the lamp but is sufficient to produce a fair light. A number of small bracket lamps, single and double, are also still in use, though no longer supplied for issue. These have a lighting capacity of 18 candle-power and are expected to consume two ounces of mineral oil per hour.

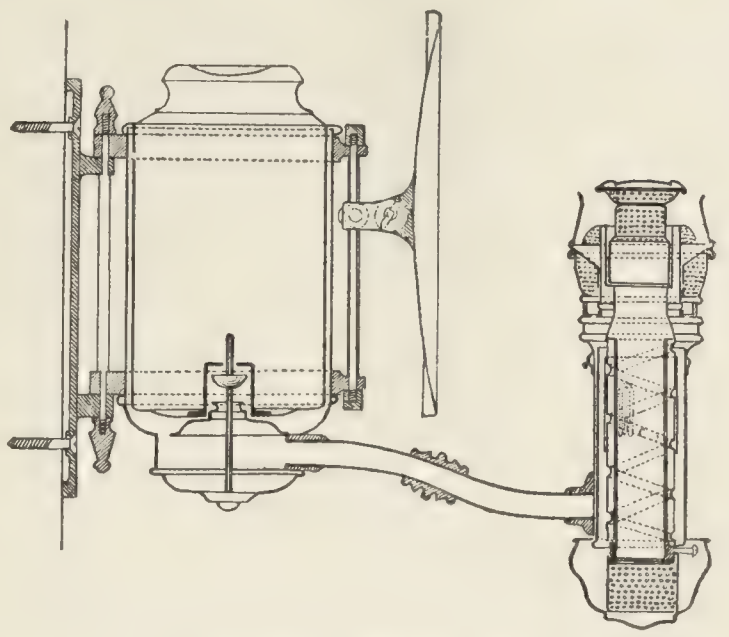


FIG. 249.—Barrack Lamp.

The light produced by these lamps is neither powerful nor of the best quality, the expense of their operation is great and they require constant care and attention. The amount of time spent in properly caring for the lamps used in our service is, in the aggregate, very great—and furnishes a strong economical argument against the use of such means of illumination. The vitiation of atmosphere by the products of their combustion is also large, and flaring, with its smoke and sooty deposits, is liable to result from any gust of air. In warm climates or summer weather the heat which such lamps evolve often renders the temperature of barrack-rooms almost insupportable; besides which they are never free from danger of fire or explosion as a result of accident or a poor quality of oil.

Coal-gas.—This is used for purposes of illumination in a few posts located in the immediate vicinity of large cities, the supply being derived from the local mains. Usually it happens, however, that even under conditions when gas might be obtained the garrison is required to use mineral oil, much to its unnecessary disadvantage.

Coal-gas, as its name implies, is a mixture of a number of gases produced in the dry or destructive distillation of coal. About ninety per cent. of coal-gas is made up of so-called diluents, which do not give much luminosity but dilute the heavy hydrocarbons, which might otherwise give a smoky flame. These diluents are chiefly hydrogen, methane and carbon dioxide. The actual illuminants, constituting only about six per cent., consist of gases rich in carbon, as ethane, acetylene and olefiant vapor. The impurities make up the remainder. Every cubic foot of ordinary coal-gas

yields, on combustion, roughly half its own volume, or 0.52 cubic foot, of carbon dioxide and 1.34 cubic feet of watery vapor. Knowing the quantity of gas which each burner consumes hourly, the average in our service being six cubic feet, there is therefore no difficulty in calculating the vitiation of the air from such causes. Combustion, however, with ordinary burners is never complete; thus slight traces of carbon monoxide will generally escape combustion, while with a rich gas distinct traces of acetylene are generally given off. The actual products of combustion vary with the quality of the gas and the completeness of the process. When coal-gas is partly burned, the hydrogen and light and heavy carburetted hydrogens are almost destroyed. Of the resultant, nitrogen constitutes about sixty-seven per cent.; water, sixteen per cent.; carbon dioxide, seven per cent.; and carbon monoxide, five to six per cent. A small amount of sulphur dioxide and ammonia are also found. Where the combustion of coal-gas is perfect, there will be little production of carbon monoxide. Speaking generally, it may be said that each cubic foot of gas burnt per hour from ordinary flat burners vitiates as much air as would be rendered impure by the respirations of an individual during the same period.

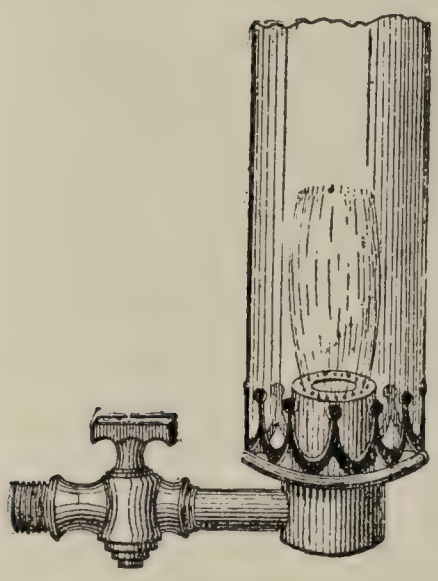


FIG. 250.—Argand Burner.

The complete combustion of a given volume of coal-gas must, on theoretical grounds, give rise to the production of exactly the same products of combustion in whatever burner the gas is consumed. It follows, therefore, that if the consumption of gas be low, the evolution of gaseous impurities will be proportionately reduced; so that, apart from mere questions of economy, a burner which consumes a relatively small amount of gas, to say nothing of the superior light it may give, must be preferable on that account from the sanitary point of view. The relative hygienic advantages of certain burners are therefore well worthy of consideration.

The most simple gas-burner is the common pattern giving a flat, butterfly-shaped flame. This is the burner employed wherever gas is used in our barracks, and, as supplied, is capable of burning six cubic feet of gas hourly. Its illuminating value is 16 candle-power. This burner has many bad qualities, especially for the interior lighting of barracks and hospitals. The light is unsteady and trying to the eyes and the flame is also liable to smoke in air-currents. The latter may, however, be prevented and the light softened by the use of globes. The amount of gas used is proportionately large and its combustion is not complete, thus causing great vitiation of the atmosphere of the room. The quantity of heat developed by the combustion of gas in burners of this character is also very great. These defects are fully appreciated in civil life, and during the past few years various gas-burners have been introduced which not only increase the luminous intensity of combustion but also diminish the consumption of gas, while special arrangements decrease the vitiation of the air. While many varieties of these burners have been devised, the Argand burner, the Wenham regenerative burner and the Welsbach burner are probably the best representatives of their types.

The Argand burner is a great improvement over the ordinary flat burner, consuming less gas and at the same time yielding more light. In this contrivance the gas escapes through a series of small holes disposed in a circle around an annular burner, itself surrounded by a cylindrical glass or globe. The combustion of gas is more complete by this method than with the flat burner and the flame is more steady. The gas arrives at the burner under a low pressure; some modifications of the apparatus possessing an automatic pressure regulator.

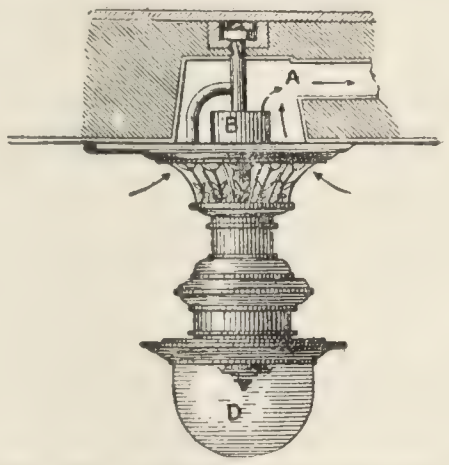
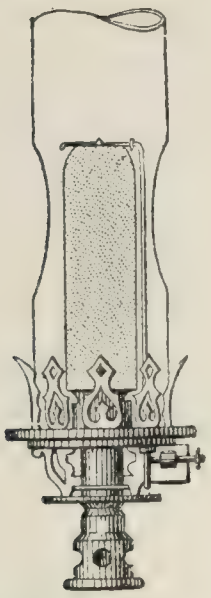


FIG. 251.—Wenham Regenerative Burner.

Burners of regeneration are based on the principle that illuminating gas burns better, is more completely consumed and produces a stronger light if it is mixed with very hot air at the moment of combustion. For the attainment of this object, the heat of combustion is used to elevate sufficiently the temperature of the cold air entering the apparatus. In the Wenham burner the most important part is the cylinder B, through which small pipes serve for the entrance of air, while the heat and gases of combustion escape through intermediate pipes to pass out at A. To light the burner the globe D is removed. The flame must be kept low at first, since otherwise the glass is liable to be shattered. The burner gives a steady white light and is very economical of gas. By its use there is not only little or no vitiation of the atmosphere in the room, but when in operation the apparatus promotes ventilation by acting as an efficient heat-extracting shaft. This type of burner is excellently adapted for use in barracks where gas is employed.

Of the various forms of light derived from coal-gas, that yielded by the Welsbach burner stands out pre-eminently as the best. This burner, when complete, may be said to consist of two essential parts. The first is an ordinary but carefully adjusted burner of the Bunsen type, in which air and gas are mixed before combustion in the proportion of thirty parts of gas to seventy of air, producing a colorless or faintly blue flame. The second part is a fine, gauze-like mantle composed of nitrates of the alkaline earths, cerium, lanthanum, thorium and zirconium, which is suspended in the flame by a forked support of magnesium silicate, itself luminous when hot. The flame and mantle are enclosed in a glass chimney, which serves to protect the fragile mantle from accident and also to keep the flame steady. The principle of the Welsbach burner depends upon the conversion of heat into luminous rays, the mantle being rapidly raised to incandescence by the heat of the burning gas. The light given by this burner is very white, brilliant and steady, being much like that of the electric light. This apparatus consumes only about half the gas required for combustion by an ordinary flat burner, while at the same time it gives off more than three times as much light. The mantles are somewhat fragile and are said to last only 800 to 1,000 hours. Their increased


FIG. 252.—Welsbach Burner.

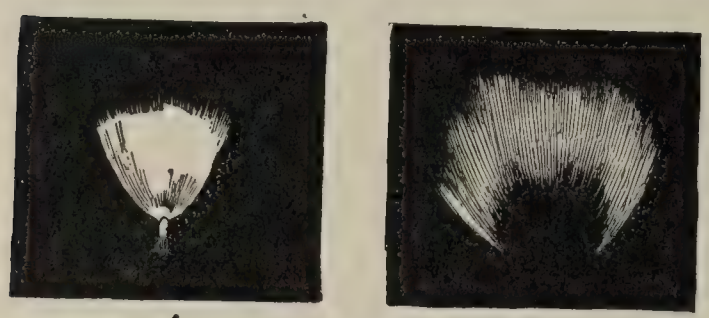
cost in this respect, however, is more than made up by the very great saving of gas thus rendered possible; but this fragility is none the less a serious drawback for the use of these burners in barracks, where they may be subjected to less careful usage. In hospitals, where gas is provided, this pattern of burner should always be supplied.

Acetylene.—This gas, from its many admirable qualities as an illuminant, its readiness of preparation, ease and safety in handling and the small size and comparatively light weight of the simple apparatus used in its generation, is especially suited to the needs of the military service. Far superior to candles, oil or coal-gas, it is probably surpassed, from the sanitary standpoint, by the incandescent electric light alone.

Acetylene is a pure hydrocarbon gas, having the chemical formula C_2H_2. It is produced from calcium carbide by the addition of water in excess, according to the following reaction:

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2.$$

One pound of calcium carbide, to which nine ounces of water have been added, will yield six and one-half ounces of acetylene gas—or about five cubic feet. This gas is clear and colorless, has a distinctive odor resembling garlic and burns with a flame of intense brilliancy, the spectrum being almost identical with that of the sun. Acetylene is the chief illuminating principle of ordinary coal-gas, though present in the latter in the proportion of but four to six per cent. It is a permanent gas under the low pressure in which it is used, and when mixed with air in about the same proportions as coal-gas it acts in a similar manner and may be stored, handled and distributed in the same way. A certain prejudice has existed against acetylene from accidents which followed its use in the early form of generators; but modern apparatus entirely eliminate all danger of use. Calcium carbide, however, should be kept in water-tight metal cans when stored, and should not be exposed to the weather. Mixed with air, acetylene appears to be no more explosive than is coal-gas; and when escaping from leaky joints it may be safely lighted, this being the usual method of locating imperfections in distributing pipes. Fatal asphyxiation appears to be much less liable to occur with acetylene than with ordinary gas.



A *B*

FIG. 253.—*A*, Acetylene, one-half-foot burner; *B*, Gas, six-foot burner. Photographic exposure of three seconds.

The quality of the light given by acetylene is excellent, being clear and white and strongly resembling that given by electricity. The light is also very intense and steady; far surpassing coal-gas, as used in ordinary burners, in these respects.

Calcium carbide is now made in vast quantities, and at slight expense, by fusing calcium and carbon together in the electric furnace. A 25 candle-power burner, which consumes but one-half a cubic foot of acetylene per hour, costs for its operation about two-fifths of a cent hourly, which is less than that of operating a 6-foot flat gas-burner and about the same as the electric light under the conditions usually found in this country. The price of calcium carbide, moreover, is steadily falling as a result of more economical methods of production. Recent investigations made in

France by Hospitalier, comparing the cost of acetylene with other illuminants, expressed in cents and terms of one candle-power for one hour, gave the following results:

Illuminant.	Cost in cents.	Illuminant.	Cost in cents.
Tallow candle	4.00	Petroleum	.54
Gas, open burner.....	.76	Gas, Welsbach burner.....	.32
Edison, incandescent	.6	Acetylene	.2

The scheme of operation of modern acetylene generators is extremely simple and merely requires the automatic control of contact between the carbide and water. These generators are divided into two main forms; one in which the water is fed to the carbide in small quantities, and the other in which the carbide is fed to the water. The first form of apparatus is not without danger and is wasteful of gas. The second form appears to be largely free from defects and is compact, readily operated and free from danger. An acetylene generator capable of thoroughly lighting a company barrack or post hospital need not be greater in bulk than a hogshead, while one capable of illuminating a field hospital of one hundred beds is not larger than a pork barrel; the latter apparatus weighing when complete, without water or carbide, but little more than one hundred pounds. These generators are thus very transportable and are capable of excellent use in hospitals and headquarters offices in the field. In permanent buildings, acetylene is distributed by ordinary gas-pipes; but in the field rubber tubing may be used, this being rapidly strung from one hospital tent to another—when several tents are pitched together—below the ridge-poles. A special burner is required for the combustion of acetylene, in which a flat flame is produced by the reciprocal action of two tips. If the gas be moist, carbonization is liable to occur on these tips, which should therefore be frequently inspected. Usually combustion of the acetylene is complete, and an object, such as a white plate, shows no trace of soot when held in the flame.

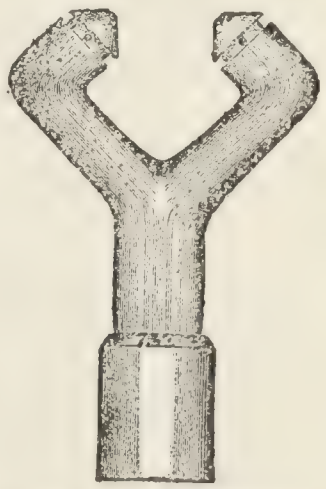


FIG. 254.—Burner for Acetylene Gas.

Acetylene generators are made in an almost infinite number of varieties and sizes, according to the special purpose for which they are intended. For barracks and post hospitals, an apparatus having a carbide capacity of twenty-five pounds and capable of supplying illumination at the rate of one 25 candle-power burner for 250 hours will usually be sufficient. To ascertain how long such a generator will supply the number of burners desired, it is only necessary to divide the number of hours of service by the number of burners required. Thus with an apparatus like the above, fifty burners may be burned simultaneously during a period of five hours—but usually only a small proportion of the burners provided would be used for the same period. In a Colt acetylene generator used in a barrack-building at Washington Barracks, containing forty-five men, re-charging of the apparatus was necessary but once every three days. This form of generator is simple in the extreme, consisting of only three principal parts:

First. A water-supply tank, holding only sufficient water for genera-

tion and for keeping the residue in a liquid state; the supply of water being inserted and the residue drawn off without the use of stopcocks or valves and without opening the generator, no gas escaping and no air being admitted.

Second. The carbide holder, having a conical bottom secured over the water supply and provided with a carbide feeding-valve of simple and positive action.

Third. A gas-bell to enclose the carbide holder and to connect it with the water-supply tank, separately water-sealed. The gas-bell regulates the feeding of the carbide from the carbide holder, and is so arranged that the latter can be filled without removing the bell and without the escape of gas or admission of air.

Incidental to the generator proper is an improved blow-off. Any soldier of ordinary intelligence can re-charge one of these generators in a few minutes. The residue is of a creamy consistency with practically no odor and can be poured into drain pipes or sewers. This residue, being nothing but thick milk of lime, is obviously an excellent disinfectant. Where a sewer connection is convenient, the residue flush-out pipe of the generator may be connected with it and the apparatus filled with water by means of a bucket, or, if a water service is convenient, it may be connected so that by opening a faucet and allowing the water to run through the machine the latter cleans itself; so that absolutely no other attention is necessary except to open the filler-cap and pour in a fresh supply of crushed carbide. If no sewer connection or water service is convenient, the cleaning out of the machine is done by putting a bucket under the flush-out pipe and pouring water into the bib. The amount of residue to be handled is reduced to a minimum and the method of doing it is simple in the extreme. As the gas is entirely extracted from the residue, no odor of acetylene escapes into the room.

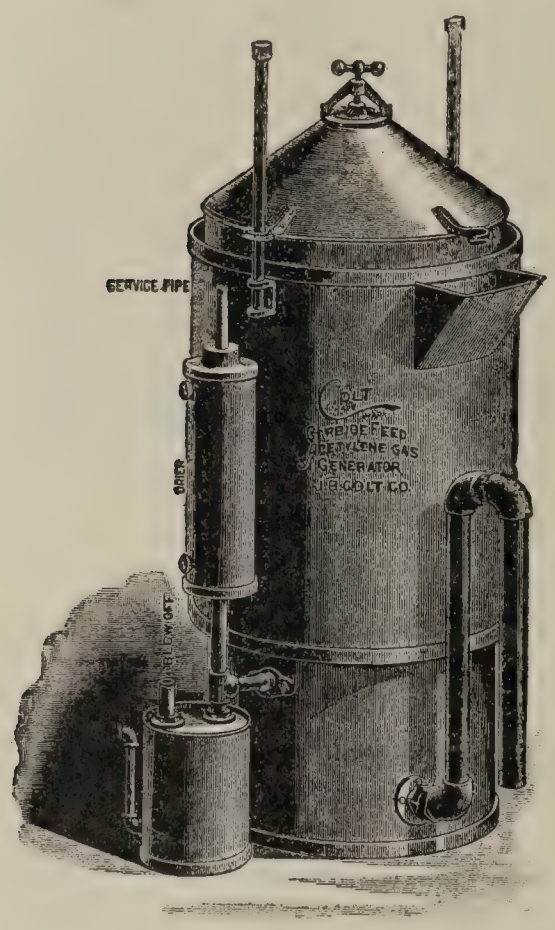


FIG. 255.—Large Size Acetylene Generator.

A small portable generator, when packed similar in shape and size to an ordinary water-pail, having a carbide capacity of two pounds and maintaining four 25 candle-power burners for four hours, possesses particular value for use in the field, for offices or operating-tents. For cleaning and charging only a few minutes are required, and, like the larger forms of generator, during operation this apparatus requires less attention than an ordinary mineral oil lamp.

Electricity.—Of all the systems of lighting in common use at the present time, the incandescent electric light must be regarded as by far the best from the standpoint of health. The light is very pure, steady and of great intensity; and is especially valuable for military use because of the slight amount of heat which it gives off, and from the fact that with

its employment no deleterious products of combustion are passed into the atmosphere of the room nor is the oxygen of the latter drawn upon for its successful operation. Electric lighting is, however, somewhat costly, and requires a special plant and trained mechanical supervision for its production. For these reasons it may not be possible, from motives of economy, to install this method of lighting in small posts, especially if these be of a presumably temporary character. In many large garrisons, however, engines are used for pumping up the water-supply and steam is kept in these engines at night in anticipation of possible conflagration. In such posts, dynamos could be driven at night by these engines with but slight original outlay, a constant saving to the government and much benefit to the garrison. In the past, repeated efforts to obtain authority to utilize power thus wasted has met with no encouragement from the authorities. Not long since, a former head of the responsible department, in refusing such a request, although shown that by this means an actual saving to the government would result, officially stated that electric lighting was still in the experimental stage—and this in spite of the fact that outside the military service electric lighting was everywhere being successfully employed to the comfort and advantage of all concerned. For this non-progressive attitude there can be no justification, and it is to the credit of succeeding authorities that such a mistaken policy has not been persevered in. As already mentioned, within the past few months certain stations have been equipped with electric lights, and it is much to be hoped that this system of lighting may be introduced into all our posts of any size or permanency. Particularly is this the case with reference to the southern garrisons, in which coolness of barracks is of great importance and where the universally open doors and windows permit of free drafts which cause smoking and flickering of the flame from burning gas or oil. For hot climates or summer weather, it should not be forgotten that the greater or less amount of heat resulting from artificial illumination means all the difference between comfort and discomfort.



FIG. 256.—Acetylene Generator, Small Size.

Illumination by electric arc lights is obviously not desirable for barracks, though these are excellent through their penetrative power for the lighting of posts. The light from the electric arc is too intense and is very unstable, while the consumption of the carbon is accompanied by a constant buzzing sound. Such lights, which are not contained in sealed glass globes, are said to vitiate the air in the formation of nitric acid. This, however, is of no importance in connection with the circumstances under which such lights should be used; and under any conditions their effects in this direction are proportionately much less hurtful than the combustion of coal-gas, oil or candles, as now supplied.

Vitiation and Heating of Air.—From a sanitary standpoint, these matters are of chief importance in the lighting of buildings; and the following table well shows the relative standing, in these respects, of the more common means of illumination:

Method of illumination.	Quantity of illuminant consumed.	Candle-power.	Oxygen removed.	CO_2 produced.	Moisture produced.	Heat Calories produced.	Vitiation equal to number of adult human beings.
Tallow candles	147 grams	16	10.7	7.3 cu. ft.	8.2 cu. ft.	1,400	12.0
Sperm candles	116 "	16	9.6	6.5 "	6.5 "	1,137	11
Kerosene lamp	60.6 "	16	5.9	4.1 "	3.3 "	1,030	7
Coal-gas No. 5 "batswing" burner	5.5 cu. ft.	16	6.5	2.8 "	7.3 "	1,194	5
Coal-gas, Argand burner	4.8 "	16	5.8	2.6 "	6.4 "	1,240	4.3
Coal-gas, regenerative burner	3.2 "	32	3.6	1.7 "	4.2 "	760	3
Coal-gas, Welsbach incandescent burner	3.5 "	50	4.1	1.8 "	4.7 "	763	2.8
Acetylene	1.0 "	50	....	2.0 "	.....	....	3.6
Electric incandescent lamp	0.3 lb. coal	16	0.0	0.0 "	0.0 "	37	0.0

With respect to vitiation of the air, it is evident that the incandescent electric light, which exerts no deleterious effect whatever upon the atmosphere, is easily to be given the first rank. Comparing other methods of illumination to this respect, after reduction to a common standard in candle-power, it is seen that the Welsbach incandescent light and acetylene gas give very similar results; the vitiation of the air from the flat gas-burners and kerosene oil-lamps used in our service being respectively about five and seven times greater than these. The heat produced by the two last-named methods, proportioned according to the light given, is thirty to thirty-five times greater than that resulting from the use of the electric incandescent lamp, while with the regenerative gas-burner the heat produced is ten times greater. The heat produced by acetylene is said to be only one-tenth that of gas when burned in an ordinary flat burner. Investigations made by the writer, at Washington Barracks, showed that of two large barrack rooms of identically the same size and construction and number of illuminating burners, but one of which rooms was lighted by coal-gas while the other was lighted by acetylene, the temperature on a warm evening in May was 7° F. higher in the room lighted by gas than in the one lighted by acetylene—both rooms having been tightly closed with all jets burning for one hour.

Where illuminants other than electricity are employed, deterioration of the air of the room, resulting from their use, can be largely prevented by placing above the burners small flues with wide, bell-shaped extremities to carry off the gases of combustion into the external air, the heat of the burners producing strong currents of air outward. Richard recommends that, when gas is to be burned in the air of a room, the small flues opening over the gas-jets should run to the chimney and discharge into a special air-shaft in the latter. This air-shaft should be of a size capable of removing (1) the volume of gas burned; (2) the volume of air necessary to burn the gas—about four times the volume of the latter—and (3) a quantity of air, in addition, which he estimated at two hundred times the volume of the gas burned. Unfortunately, such an arrangement, though good, is not especially easy of installation in barracks and is somewhat costly, and can therefore in practice be largely left out of consideration in dealing with the question of the vitiation of air by lights. The removal of the

products of combustion by the regenerative burner, as already described, is excellently accomplished.

Conclusions.—It is evident from the foregoing that, considered practically as well as hygienically, illumination in the military service—under all circumstances, but especially for stations in warm climates—should be accomplished wherever possible by means of the electric incandescent light.

Considerations of hygiene, comfort and economy, taken together, also point to the use of acetylene in all posts where electric lighting cannot be secured. The small amount of heat and atmospheric deterioration resulting from the combustion of acetylene render this illuminant much superior to coal-gas as commonly used, especially for hot climates. As compared with mineral oil, acetylene is far superior in all respects. For isolated stations or buildings it possesses special advantages, while the compactness and ready portability of the acetylene generators and distributing pipes render it especially available for stations of no great permanency or for certain purposes with troops under canvas. It is much to be hoped that the responsible authorities in our service may give this method of lighting the favorable consideration which it deserves.

In stations where coal-gas has already been introduced and cannot be exchanged for electric lighting, it is equally clear that the flat "bat's-wing" burners should be discarded, and regenerative burners used in barracks, while Welsbach burners are preferably to be employed in hospitals. Ordinarily, however, where coal-gas can be obtained, electricity can also be supplied and at no greater cost.

Mineral oil should be totally discarded as an illuminant for barracks and hospitals, under all circumstances. In view of the far better method of lighting available in the use of acetylene, this can now be done at slight original outlay and with decreased running expenses. For the lighting of small detached buildings not employed for the shelter of troops, mineral oil may be still allowed a limited use. Candles should be employed by troops only when in the field, as is practically the case at present.

CHAPTER XII.

DISPOSAL OF EXCRETA, SEWAGE AND REFUSE.

In the military service, the removal of excreta from the vicinity of habitations is of even greater sanitary importance than is the case in civil life. It has already been noted that where troops are constantly changing their residence site, as during campaign, they will not usually experience the consequences of inefficient removal of excrementitious waste; since instead of the excreta being removed from the troops, the latter are constantly being moved away from their excreta. In large standing encampments, however, the disposal of such material becomes a serious sanitary problem, directly depending in its gravity upon the relative permanency of the camp. In camps intended for long occupancy, as with fixed posts, the proper disposition of material of this character becomes literally a matter of life and death. The military sanitarian will therefore endeavor to secure its removal from the vicinity of buildings and posts; not only promptly, but also in such a manner that neither air, soil nor water shall be made impure and no opportunity shall be left for the occurrence of disease from any infectious material which it may contain. Clearly these theoretical requirements are not easily to be satisfied, and their accomplishment may be secured only by the expenditure of much labor and considerable financial outlay. For these reasons, the most efficient methods of disposal have not always been introduced into our posts during the past, particularly since many garrisoned stations were recognized as not being of a permanent character and maintained only to meet a temporary military exigency. With the abandonment of posts of the latter character, the general conditions with respect to the disposal of excreta and liquid refuse have undergone a steady improvement throughout the service.

At present, the methods of disposal of excreta and liquid wastes in our permanent posts may be classified somewhat as follows: A very few small frontier stations still in the primitive sanitary condition of privy-pit conservancy, with no provision for the disposal of liquids save the absorbing soil of their sites; a few in which earth-closets have been substituted for the pit system; a few in which, besides the earth-closet or the pit, some effort is made for the removal of liquid wastes; a few in which the drains for these liquid wastes form the rudiments of a sewerage system, by having connected with them the outflows from certain lately introduced water-closets; and lastly, the great majority provided with thoughtfully planned, carefully built and thoroughly efficient systems of sewerage. As a whole, our methods of disposing of excreta and refuse compare very favorably with those of foreign armies, particularly in those of France, Russia, Italy and Spain, in which the disposition of excreta is frequently of such character as to furnish a continual menace to the welfare and safety of troops.

The Cess-pit System.—Until a comparatively recent period, excavated pits or vaults afforded the most common means of disposing of the excreta in posts. These pits were usually deep and roughly stoned, and ultimately contained considerable quantities of putrescent and offensive matter; this giving rise to gases and liquids that only too readily polluted the air and soil around them, contaminated the ground-water and penetrated to the wells in their vicinity. The distance through which the latter action might be exerted, as already mentioned, was often considerable, depending upon the difference in depth between the privy-vault and the well, the character of the soil and the direction and rate of movement of the subsoil water. The cess-pit had also the defect of requiring the exposure of the person over a large excavation full of cold and mephitic gases; a condition which, particularly at night, may predispose to disease in the partially-clad soldier. Further, the conditions in such vaults were usually very favorable to the development and increase of many pathogenic micro-organisms. An attempt was sometimes made to limit the generation of odors by the application of earth or ashes, but these materials filled up the vault so rapidly that their use was ordinarily not long continued. Disinfectants were also sometimes employed; but only rarely, as they were not usually available for such purposes. When filled up, such vaults were rarely emptied, but were covered over and left unmarked and forgotten to remain as dangerous hidden foci of disease to future garrisons. The worst offenders in this respect were the common shallow pits dug for temporary relief, generally without authority, near the stables, corrals and married soldiers' quarters, frequently honeycombing the site of an old post. Thus it was reported from Fort Leavenworth, in 1899, that the ground around the married soldiers' quarters was so full of abandoned latrine vaults that it was difficult to find a site for a new one; in an effort to this end, six excavations had to be made before a spot was found which had not previously been used for this purpose. At old Fort Omaha, lately abandoned, privy-pits had been dug and filled so often that the soil was everywhere saturated with fæcal matter, and the ground-air so foul as to be a cause for complaint. The cess-pit system of disposal was until recently in use at Fort Keogh; the post area having in the course of time become thickly studded with deposits of filth. Of Fort Washakie, it was reported several years ago that the soil was so honeycombed with privy vaults that no new cess-pit could be excavated in the hospital yard without opening old ones. These instances are cited to show the nuisance which the privy-pit system ultimately produces. While this method of disposal may temporarily be relatively inoffensive, it is only a question of time when it will exert a most unfavorable effect upon the healthfulness of the site. Aggregations of filth of this character long preserve their original characteristics and are only slowly disintegrated by bacterial action, for the reasons detailed in connection with the bacterial treatment of sewage.

Usually a privy-pit which has been once installed, even if originally intended for temporary purposes only, is continued in use until the unsanitary conditions produced by its existence compel its abolishment. Hence the establishment of privy-pits, under any such pretext, is to be firmly opposed by the sanitary officer. Should higher authority decide to

permit their use, at least they should be specifically designated as to place and depth, filled in according to rule and marked both in place and on the post map. At permanent posts, where such old pits are known to be in existence, if close to any occupied habitation they should be reopened, emptied, limed and filled with clean earth. Wherever their use is permitted they are best cemented inside so as to be water-tight, should be disinfected, at short intervals and should be pumped out frequently by odorless excavating apparatus. The vault should be roofed in and well ventilated by long flues running through the roof; the ventilating shafts being preferably painted black. The movement of the foul air in the vault is thus rather outward by the ventilating flues than by the apertures in the seat.

At present, even in some of the most important posts, the married enlisted men's quarters are dependent upon privy-pits for the disposal of excreta. This arrangement should be done away with; water-carriage should be provided if possible, and in its absence the earth-closet system should be installed.

The vault system is still in use in several foreign armies, and under special conditions which render it much more offensive and unsanitary than is the case in the few instances in which it is still employed with us. Thus in several barracks in Paris, it is stated that immense cess-pits have been excavated beneath the buildings; sometimes these are cemented inside, but often they are so cracked as not to be water-tight and to permit their fluid contents to soak into the surrounding soil. This method of removal, however, appears to be not always regarded, by certain minds, as undesirable, since sanitary cleansing is an offensive and costly process. In the barracks just mentioned, ventilating pipes conduct outside the building all the foul gases that do not escape into the closet as a result of its greater warmth. The excreta are generally discharged into the cess-pit through untrapped hoppers, opening into a shaft which may run through many stories and is incapable of being either properly flushed or cleaned. These cess-pits are usually emptied by hand. A condition of affairs similar to the above was found by our troops to exist in many of the barracks and public buildings in the islands taken from Spain as a result of the late war. The general system of cess-pit disposal is largely used in all Latin countries, and their military services naturally share to some extent in the prevailing customs.

The Pail System.—A slight improvement over the old excavated vault is found in the pail or tub system, which permits the removal of the excreta more easily and frequently, and with less nuisance, than is the case where the cess-pit is used. With this system, a movable receptacle of the above character intervenes between the seat of the closet and the floor; the latter being raised above the ground-level and made of cement or other impervious material. When full, the tubs or pails are carried away for the disposal of their contents and are replaced by empty receptacles.

While local contamination of the soil is less than occurs with the use of privy-vaults, this system is highly unsanitary. Since earth is not used in these receptacles, their condition naturally becomes very filthy, their contents are foul-smelling, are not protected from flies, and are not rarely spilled out while being removed to the dumping-ground. This method of disposal cannot be recommended.

The Dry-Earth System.—Improving on the pail system, just mentioned, Moule showed that a slight covering of dry earth, of suitable quality and character, destroyed the offensive odor of the excreta and at the same time rapidly brought about the disintegration and disappearance of the latter. Even paper was ultimately destroyed by this means, while fæcal matter could not be detected by sight or smell after a period of two or three weeks. At the end of this time, earth which had been used for this purpose possessed a perfectly normal appearance and could, if desired, be employed over and over again. The destruction of the fæcal matter, under such circumstances, appears to be due to the action of the nitrifying bacteria present in vast numbers in certain soils.

The dry-earth system is especially adapted to posts where either the water-supply is insufficient for general water-carriage or where a doubtful permanency prevents the installation of an expensive sewer system. It may also be employed to serve a temporary purpose while a more suitable means of disposal is being introduced. It is far less offensive than the ordinary pail system, and should invariably be substituted for the use of privy-vaults in the absence of water-carriage. The installation of dry-earth closets is both simple and inexpensive.

Dry-earth latrines are used in the British and Austrian armies at a number of stations. The French use them in Algeria; though preferring the Goux modification for home stations. In our own army, the system is employed at a number of posts. It appears, on the whole, to render very efficient service — and where cause for complaint exists, a lack of the necessary details of administration can usually be demonstrated. It should be understood that the success of the system depends on proper scavenging arrangements and efficient sanitary supervision—and if these cannot be secured, this method of disposal will prove unsatisfactory and unsanitary. As with the pail system, the saturation of the soil with filth and the pollution of the ground-water are avoided. There is, however, a considerable liability to the dissemination of possibly infectious material through carelessness in scavenging. The great point of superiority of the system consists in the fact that, by its use, the excreta are promptly rendered inodorous and inoffensive, while the possible transmission of infection by means of flies is largely avoided.

One inconvenience is found in the fact that the system does not work well unless the earth to be employed is perfectly dry. In our own service, its use is particularly satisfactory on the high plateaus of the west or in other dry regions—and for the French army, Laveran states that no such excellent results can be obtained in France as are given by the system in Algeria. Another disadvantage consists in the necessity of collecting, drying and storing the earth; the supply of which to large posts, particularly during long periods of rainy weather, is a matter of considerable difficulty from the amount required. In dry western climates, the earth required can usually be dried sufficiently in the sun; but in damp localities some artificial means of drying may be necessary, as by the use of improvised kilns. Earth dried in the sun appears to be more efficient in its action; when dried artificially, it is desirable that the temperature be not raised sufficiently to sterilize it and thus destroy the micro-organisms upon which its efficiency chiefly depends.

Not only should the earth be dry originally, but it must be kept in this condition, which usually implies the erection of a suitable shelter under which it may be stored. The earth should not be lumpy but should be in fine particles, to secure which quality it is best sifted and screened. There is much choice in the character of the earth to be used; the best are loamy surface-soils, vegetable moulds, dry clay or brick-earth. Chalk, gravel or sand give only inferior results. Sifted coal-ashes may be used for this purpose, but while they are an efficient desiccant their deodorizing powers are very slight. Sawdust has been tried at Fort Missoula with satisfactory results, as a substitute for dry earth. Charcoal is an excellent deodorizer and is used abroad in earth-closets for this purpose; it is not required in the military service, where careful sanitary supervision and the generous use of dry earth of good character should satisfactorily answer all purposes.

In the British army, the amount of dry earth to be provided is based on the estimate of one cubic foot per month for each soldier. This allowance is insufficient and does not permit that free use of earth upon which the special value of this system depends; to obtain the best results, twice the above quantity will be required. The amount of earth necessary for covering each dejection obviously varies with the amount of the latter. Usually the quantity of earth should be about five times the combined weight of the solid and liquid excreta. Thus with four ounces of fæces and seven fluid ounces of urine the amount of earth required would be about four pounds. Vallin states that where clay soil is used, about twenty per cent. more earth is required to obtain the same results than where garden loam is employed.

For the proper operation of the dry-earth system, the earth must be systematically used and the dejecta promptly covered after their deposition. Where a number of fæcal dejections are passed without being covered individually, the mass disintegrates slowly and gives off odors. In military latrines, the dry earth is usually kept in boxes on the floor of the various compartments, a scoop being provided by which the earth can be distributed as required. As might be expected, however, soldiers are prone to neglect its use, and it will not rarely be found necessary to issue special orders on this subject and hold company commanders strictly responsible for the condition of the latrines of their respective organizations. The plan sometimes practiced of having the room-orderlies look after the sprinkling of the latrine receptacles is unwise; since this can be done by them only at infrequent intervals, between which the system becomes offensive and unsatisfactory. In some foreign services, a simple arrangement has been tried, by which a sufficiency of earth is automatically deposited on the excreta by means of a valve, on pulling a cord. This arrangement has no advantages over the box of earth and scoop already mentioned, nor can the deposit of earth be as efficiently disposed as by the latter.

Nothing but fæces and such urine as may be passed during the act of defæcation should find their way into the receptacles of the earth-closet system, as the absorbent capacity of the earth is limited and its dryness is essential to the success of the system. As a result of this fact, efforts have even been made to catch, separate and conduct away such urine as might be passed during defæcation; but this precaution is scarcely necessary, as

sufficient earth can readily be provided to take up that amount of fluid. Urine passed at other times should not, however, be discharged into the dry-earth closets, but should be disposed of in some other way.

Where the dry-earth system is in use, the latrine-building should preferably be constructed of brick, with concrete flooring raised well above the ground. The building should not be too close to the barracks, and should be so located as not to become in any way a possible source of contamination to a water-supply. Ready means of access for the scavenger should be provided at the rear, as by a hinged flap opening outward, so that the contents of the receptacles need not be removed through the building itself. The floor of the latrine should slope to a certain point, so that any liquid which may be spilled over it may run down where it can readily be collected. The receptacles should not be too large, the capacity of each being not over eight cubic feet, so that the frequent removal of their contents may be imperative. If possible, such receptacles should be kept in duplicate, so that those removed for dumping, cleaning and deodorizing may be replaced at once by others. Some of the large troughs used in our posts are very unwieldy and cannot be dumped, requiring to have their contents shovelled out; with receptacles of this character, the pollution of the ground in the vicinity of the latrine is certain to occur during scavenging. The receptacles for earth-closets should always be of impermeable and non-absorbent material and should never be of wood—although wooden boxes or drawers are generally in use where this system is in operation in our army. Such wooden boxes absorb much excretal matter, the odor of which no subsequent cleansing or amount of deodorants will remove. Galvanized-iron receptacles are very satisfactory for this purpose. If force of circumstances compels the use of wooden receptacles, their surfaces should be thoroughly tarred and the operation afterward repeated at intervals of two months. Whatever the material and form of the receptacles, they should fit sufficiently closely to prevent urine and fæcal matter from getting into the slide space. The latter should be ventilated by a shaft, as already suggested in the case of privy-vaults. To increase its aspiratory effect in winter and carry off any odors, the stove-pipe should pass up through this shaft, which should be made large enough for the purpose. Unless some such ventilating arrangement is made, in cold climates the odors given off by the dejecta are promptly aspirated up into the heated room before any covering of earth can be applied; and where a latrine is in constant use, the air of the room is generally bad at all times as a result. If possible, the receptacles should be kept at a point above the freezing temperature. The seats should be hinged, so as to allow a more thorough cleansing of the subjacent space when required; for the same reason, the floor of this space should be of cement and should slope slightly outward.

All scavenger work in connection with the dry-earth system is preferably to be performed by civilian labor and not by that of soldiers. Such work is degrading to the military man, and although often necessary in the field, in garrison is surely not in his proper line of duty. Where civilian scavengers are employed, careful oversight should be had over their work and methods. The majority of them slight their tasks to a greater or less degree, and the system is proportionately unsatisfactory as a result. Thus at Fort Sam Houston, in 1898, recommendation was made for the

abolition of the dry-earth system because of carelessness and inefficiency in the carrying out of its details. Under many circumstances, also, the securing of the necessary scavenger labor at reasonable cost is a matter of difficulty and is sometimes impossible—particularly among the native white population in the west. Thus at Boise Barracks, in 1895, the dry-earth system installed several years previously had to be abandoned, and a return made to the old system of privy-pits, by reason of the fact that the necessary civilian scavenger labor could not be secured for the post.

The expense of caring for earth-closets is not small, and the more frequently the cleaning is carried out the greater the cost of operation—hence there is always an inducement to economize in labor at the expense of health. The receptacles should be cleaned out, however, at least once every two days in warm weather—and a daily emptying is desirable. During cold weather, less care is required and a cleansing twice weekly is usually sufficient. It is important to use an ample amount of earth in covering the dejections during cold weather, since otherwise the contents of the receptacle may be frozen to its sides and bottom and be removable only with difficulty. The collection of the excreta is best made at night between the hours of taps and reveille, when the closets are not in use and any nuisance arising from the operation is not observed. The refuse should be carted away to a distance of at least one mile for final disposal, preferably by burial. In the tropics, the natives who perform this duty require careful watching, since otherwise they are liable to deposit the contents of the carts on the surface of the ground instead of in trenches. The night-soil should not be buried at too great a depth, however, but should be given only a superficial covering of earth, since when buried too deeply the soil from the closets remains much longer in its original foul condition, through the small numbers of the bacteria upon which its destruction depends. In cold climates, the sanitary officer should ensure that sufficient dry and loose earth has been stored by the scavenger to last through the period of cold weather.

The desire so commonly manifested by line officers, to have weak disinfectants used in earth-closets in order to control any odor which may be present, is due entirely to a misconception of the processes upon which the efficiency of the dry-earth system depends. These disinfectant substances inhibit the action, if they do not destroy the vitality, of the bacterial ferments present in the soil; there is therefore no disintegration, oxidation and nitrification of organic matter, and the whole process by which the excreta are destroyed is arrested. It is because of the absence or infrequency of these nitrifying organisms in such soils as chalk or sand that they are inefficient when used in earth-closets; hence the addition of any substances which would impair the activity of such bacteria as may be present should obviously be avoided.

There is no reason to suppose, in view of the well-known viability of typhoid bacilli in contaminated soil, that dry earth renders innocuous the infectious material contained in the dejecta. Hence this system offers certain facilities for the spread of infectious disease not found in the disposal of excreta by water-carriage. Thus Moore showed that, in 1894, in an epidemic at Leicester, the typhoid cases were much more numerous in those districts where the fæcal matters were collected in tubs; an epidemic

in one street showing proportionately five times as many infected houses among those using the tub system as among those provided with water-closets and sewers. At Newcastle-on-Tyne, the typhoid cases were twice as numerous in those houses provided with the dry-earth system as among those provided with water-closets. He also found that at Birmingham, in the same year, the typhoid incidence was one and one-half times greater in houses using pails, as compared with those possessing water-closets; with regard to second cases of typhoid fever in families, one occurred in every fourteen houses using pails and one in every twenty-two houses using water-closets.

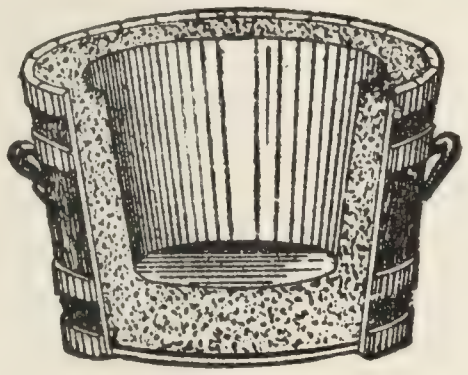


FIG. 257.—Goux Receptacle, with Absorbent Lining.

The Goux System.—This is a refinement of the ordinary dry-earth system, as just described. In it, the pail or tub is lined with some absorbent material, such as peat or a mixture of tan, sawdust and soot. The material is pressed firmly against the sides of the container by means of a mould; the latter being afterward withdrawn, leaving a lined cavity for the reception of the excreta. Nothing but fæces and such urine as may be passed during the act of defæcation is to be deposited in these tubs. When full, any projecting filling is shaken down from the sides so as to cover the excreta prior to its removal. No fluid appears in the receptacle and no offensive odor is disengaged. Like the dry-earth system, the Goux system has the great advantage of being readily put into operation, and when properly managed it gives excellent results. This system is used in both the French and German armies at stations which possess no sewerage. In the German army, powdered peat is used as the lining material; but in the French service, charcoal, ashes or any drying substance is employed.

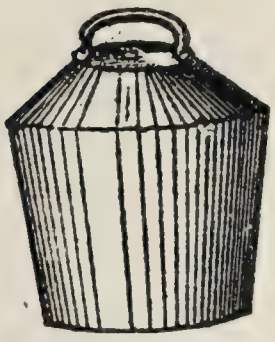


FIG. 258.—Mould Used in Lining Goux Receptacle.

SEWERAGE.

The removal of excreta by water-carriage is the cleanest, readiest, quickest and, in many ways, the least expensive method for its disposal. A piped water-supply, necessary for other purposes, furnishes at once a motive power at the cheapest rate; and where channels are necessary for the conveyance away of the waste or dirty water used for domestic purposes in a post, they can usually be employed for the removal of excreta also with but little alteration. It would obviously be a waste of economy to allow this foul water to pass off without applying the force which is present in it to other purposes. A water-carriage system, once established, thus costs little or nothing for its operation; the latter being automatic and without dependence upon individual effort. The conveniences are much greater with such a system of disposal, and the encouragement thus given to a more liberal use of water conduces to both health and cleanliness on the part of troops.

Since by the use of water-carriage all liquid or excretal waste leaves the military community a short time after it becomes refuse, it is evident that this system is far superior to privy-vaults and earth-closets for the

disposal of excreta, and at many posts, within the past decade, sewerage systems have been installed to take the place of the less sanitary methods of disposal which had previously been in use. At other garrisons, however, this improvement has not been made; either because of the uncertainty of continuance of the post as a station for troops or because of an insufficient water-supply which would render adequate flushing impracticable. At some few posts, also, the problem of sewerage and water-supply has been complicated by a winter temperature not rarely reaching forty-five or fifty degrees below zero—a degree of cold at which no water-carriage system of disposal could be expected to remain free from the danger of freezing and breakage, under the conditions usually found in the military service, without a disproportionately high financial outlay.

It is important to remember with reference to sewerage that no improvised arrangement, inferior apparatus or poor workmanship should be countenanced. Unless everything connected with the system is of the best quality and eminently adapted to the purpose for which it is intended, the results will be uniformly unsatisfactory. Makeshift appliances are to be avoided, since as compared with a poor sewerage system, the dry-earth closet is a sanitary improvement. Thus at Fort Sill the drainage system, originally poor, was soon reported as being beyond repair, while complaints with reference to the stench and frequent overflow were common.

In general, to make a success of any system of sewerage, it is essential that there be a good supply of water, well-constructed and ventilated channels, a proper outfall and a suitable and inoffensive means of disposing of the sewage. If these requirements cannot be united, the sewerage system will constantly cause annoyance and may become a source of considerable danger. The main objection to sewerage systems is that they create underground channels connecting houses, which permit the transference of effluvia from place to place. This objection, however, is against an error of construction and not against the plan as properly carried out. A practical fault in the system is that the pipes may break and their contents contaminate the soil, and this is a great evil which it requires much care to avoid.

Although in discussing the question of drainage and sewerage it is necessary at times to touch within the province of the sanitary engineer, the minutiæ of engineering cannot of course be considered in this volume.

Sanitary Value of Sewers.—There is no more important subject than that of drainage and sewerage, so far as regards the local propagation of disease, and its details are worthy of the most careful attention on the part of sanitary officers. It may be accepted that, whatever be the defects of sewers, they are much more than counterbalanced by their advantages. Waring says, with reference to this subject: "Defective though they often are, whether in the house or in the street, they have probably been, next after the introduction of a pure water-supply, the most important factor in the reduction of the death rate." The difficulty of proving this proposition statistically consists in the number of other conditions at the same time affecting the health of soldiers, outside those of sewerage; from civil life, however, illustrations with respect to this point can be found in the vital statistics of municipalities for periods before and after sewerage systems were introduced. Thus Oldright gives the following comparison of death

rates, before and after the introduction of marked sanitary improvements of this character, in various English towns.

Place.	Average mortality per 1,000, before construction of sanitary works.	Average mortality per 1,000, after construction of sanitary works.	Saving of life, per cent.	Reduction in mortality from typhoid fever, per cent.
Banbury	23.4	20.5	12.5	48
Cardiff	33.2	22.6	32	40
Croyden	23.7	18.6	22	63
Dover	22.6	20.9	7	36
Ely	23.9	20.5	14	56
Leicester	26.4	25.2	4.5	48
Macclesfield	29.8	23.7	20	48
Merthyr	33.2	26.2	18	60
Newport	31.8	21.6	32	36
Rugby	19.1	18.6	2.5	10
Salisbury	27.5	21.9	20	75
Warwick	22.7	21	7.5	19

Simon found that after the introduction of sanitary improvements, consisting chiefly of the installation of sewerage and a better water-supply, the death rate from disease was decreased in nineteen out of the twenty-five English towns studied by him—the average reduction of mortality in these nineteen municipalities being 10.5 per cent. With respect to typhoid fever, there was a reduction in twenty-one towns out of twenty-four; the average reduction in deaths from this cause being 45.4 per cent. In nine of these towns the reduction amounted to over 50 per cent., and in one town to over 75 per cent.

Oldright gives the following figures as illustrating the corresponding decrease in typhoid fever which resulted from the gradual establishment of sanitary improvements in several German cities:

City.	Period.	Sanitary condition.	Death rate per 1,000 from typhoid fever.	Period.	Changes in sanitary condition.	Death rate per 1,000 from typhoid fever.
Frankfort-on-the-Main.	1854–59	No sewers.	.87	1875–80	Sewerage completed.	.24
Dantzic	1865–69	No sewers, no proper water supply.	1.08	1871–75	Water-supply introduced.	.90
				1878–80	Sewerage added.	.18
Munich	1854–59	No regulations for keeping soil clean.	2.42	1860–65	Sides and bottoms of cesspools cemented.	1.68
				1866–73	Partial sewerage.	1.33
				1876–80	Sewerage improved.	.87
				1881–84	Sewerage still further improved.	.17

The decreased liability to the contraction of typhoid fever where there is a general sewerage system, as compared with dry-earth closets, has already been noted.

Sewerage Systems.—Sewers may carry off storm water, excreta and liquid waste; liquid waste and excreta; or finally, liquid waste alone. The first or so-called combined system is generally used in our posts; the heavy rains occurring from time to time being of much advantage in flushing out and scouring the sewer channels. The separate system, carrying only liquid waste and excreta, costs less for construction, need be of no great size and hence can be more thoroughly flushed and is more liable to run full. The pipes may be closely proportioned in size to the daily flow of sewage, which can be calculated with some degree of accuracy from the amount of the water-supply. Separate sewers have no special advantage for military posts except in the tropics, where the long dry season and subsequent period of torrential rains would render a combined system, operating satisfactorily under all conditions, unduly expensive in both construction and operation. In the third class are included those sewers which merely remove waste-water from habitations; the solid excreta being disposed by the dry-earth system, as at Forts Sill, Bayard and other posts. The sewage removed from barracks, however, is a very complex liquid where all liquid wastes are removed by the same water-carriage system. The kitchen-waters contain vegetable and animal refuse, and those from baths and lavatories carry soap and detritus from the surface of the body and resulting from the washing of clothing. To these is generally added more or less urine, and in a few instances a small number of water-closets may discharge into the sewerage system. Clearly the sewage from liquid waste alone may be so impure that there is no sanitary advantage in providing for the disposal of the excreta, either solid or liquid, by any separate system.



FIG. 259.—Ovate-Shaped Sewer.

Construction of Sewers.—In the separate sewerage system, where the amount of sewage is fairly constant, the pipes are small and frequently run nearly full, a circular form of pipe gives satisfactory results. If storm-waters are also admitted to the sewerage system, however, conduits of this shape carry their contents slowly and with only feeble force except at such times as storm waters are passing; fæcal and other solid matters accumulate along the side and flushing is difficult. Under such conditions, where a variable flow must be provided for, the best form of sewer is that which is ovate in transverse section; since this shape, with the small end down, affords sufficient space for a temporarily increased outflow and presents the advantage of a deep narrow stream, by which the deposition of sewage is prevented and the maximum scouring effect is secured with the least quantity of water. Engineers advise that all sewers over eighteen inches in diameter be built in this form. It appears to be accepted that the best shape for sewers of this general type is where the horizontal diameter is two-thirds of the vertical height, the radius describing the invert being one-fourth the horizontal diameter. The semicircle drawn upon the horizontal diameter becomes the upper part of the sewer, while the segment drawn on the radius becomes the invert.

It sometimes happens that, impressed with the desirability of removing sewage from habitations, post authorities have used wooden drains, in the absence of more desirable material, as a means for its discharge. It is

only a short time before such conduits become leaky, clogged and saturated by their contents and thus become long permanent cesspools. Such improvised arrangements are to be condemned. If higher authority permits their use in spite of protest, as has been done, at least they should not be laid flat, as is usually the case, but should be set at an angle so as to give the fluid its greatest possible depth and force and thus prevent deposit.

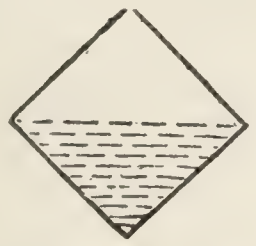


FIG. 260. — Box Drain, Placed Angle Down so as to Avoid Deposit.

As to material, large sewers are generally made of brick, set in cement and given a smooth inside coating of the same material. In the construction of brick sewers, they must be strongly put together and set on a firm bed, as otherwise they are liable to settle and develop inequalities in their level. Sewers less than eighteen to twenty-four inches in diameter are generally made of well-glazed vitrified earthenware pipe. The strength of these is usually tested by placing heavy weights on them or by dropping weights upon them when in the trench. The best test, however, is that of hydraulic pressure from the inside, for pipes which have fire-cracks and outwardly appear to be of poor quality will often stand this natural test more satisfactorily than those of better general appearance. Iron pipes must be used when any unusual strain or pressure has to be borne, as where the sewage is carried across a ravine.

The pipe most commonly used is the cylinder having a socket at one end into which the next pipe fits to form a joint. The space between the spigot and the socket is generally filled with cement to make the joint water-tight, but care must be taken that this material does not penetrate to the interior of the pipe and afterward serve as an obstruction to the flow of sewage. To prevent the cement from passing through the joint, tarred gaskets are generally used; a luting of clay is sometimes employed for the same purpose, but this is less satisfactory as it is washed out of the joints in a short time. After cementing, each joint should be carefully examined on the inside, and any cement which may have been pushed into the interior should be removed before the next section of pipe is laid. Joints made in this manner are water-tight and excellently resist the disruptive encroachments of the roots of trees; once set, however, pipes thus laid are very solid and cannot be opened for examination, in case of stoppage, except by breaking one of the sections. Sewers should of course be water-tight, and a cemented joint has much to commend it on this account. Laveran states that in certain French garrison towns, where the subsoil has been contaminated by leakage from sewers, the subsequent opening up of trenches in such polluted ground has been invariably followed by outbreaks of typhoid fever.

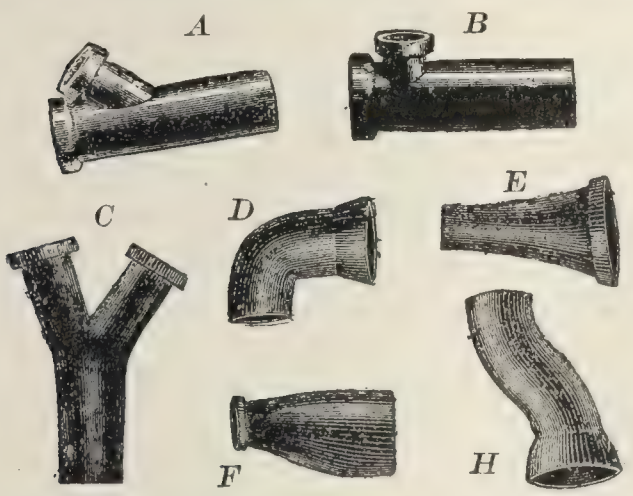


FIG. 261.—Common Modifications of Sewer Pipe. *A*, T-pipe, for use in ventilating and for inspection openings; *B*, Y-pipe; *C*, V-pipe, for junction where the main drain runs in a direction different from either branch; *D*, bend or elbow; *E*, diminishing pipe; *F*, increasing pipe; *H*, an offset, for accomplishing a slight deflection in direction.

Want of attention to the foundation of sewers, especially where earthen-

ware piping is used, is one of the most common causes of deposit and of sewage pollution of the soil. The foundation upon which the sewer rests should be firm and solid; if pipes are used, small excavations should be made to receive the shoulders, so that these should not be called upon to bear the entire weight of pipe, contents and overlying earth, with no support beneath the body of the pipe to prevent it from cracking or breaking. Provision must also sometimes be made for carrying off the ground-water by the use of loosely jointed drains or a combination sewer-pipe in which a flat, hollow bottom forms a porous subsoil drain. Where the ground water is very high, as at Jackson Barracks, it is often impossible to construct underground sewers and cemented open drains may be used under such conditions.

The direction of a sewer should be as straight as possible in order to maintain the maximum velocity of flow; if it requires to be changed, the curves should be gradual—the radius of the curve being not less than ten times the cross-sectional diameter of the sewer. Where sewer pipes are so laid that the alignment is imperfect in both the horizontal and vertical planes, the depressions will serve for the accumulation of matters which generate foul gases. In some instances, the inequalities of level may be sufficient to form running-traps and thus divide the sewer into dead sections; but with any inequality of level in the floor of the sewer the movement of its contents is materially hindered. Thus the sewerage system at Fort Huachuca, in 1896, had to be opened up for this reason. Junctions of sewers should be made at acute and not at right angles, as the interruption of the stream and the eddies thus formed will cause a deposit which, once commenced, rapidly increases in bulk. Sewers of unequal sectional diameter should not join with level inverts, but the lesser or tributary sewer should have a fall into the main sewer at least equal to the difference in the sectional diameter. If a manhole is used for the junction, the bottom can always be so constructed as to give the required flow in the direction of the movement of the main current. As a general thing, when a small sewer pipe has to be received in a larger one, an "increasing" pipe is used to prevent a bad joint.

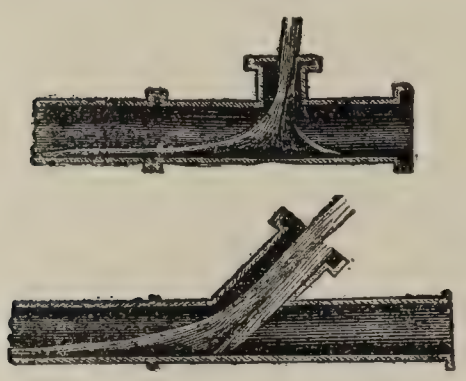


FIG. 262.—Improper and Proper Angles of Junction in Sewer or Drain Pipes.

After the sewer has been laid and before the trench has been filled in, the pipe should be tested for strength and tightness by temporarily fixing a bend and two lengths of pipe so as to give four or five feet of water pressure. Any leaky joints which may be found can be made tight by embedding them in concrete or cement. The water should not be discharged from the pipes until the filling-up of the trench has been completed, since any cracking or breakage resulting from the operation of filling will thus be shown by subsidence in the water-level.

A good sewer, properly laid, is indestructible except by violence; while a poor line, poorly constructed, is a never-ending source of trouble, expense and danger. Large sewer systems cannot be properly laid by unskilled workmen and inexpert overseers.

Size of Sewers.—The probable amount of sewage requiring removal

should be estimated in advance, and the size of the sewer proportioned accordingly. If the conduit be too small, there will be flooding of the connections with the lower portion of the sewer, or system of sewers, with every sudden influx of storm water; if sewers are too large, there is needless expense of construction, sluggish flow and opportunity for the development of putrefactive processes in their contents. In general, sewers having a diameter of less than nine inches are liable to obstruction and cannot be recommended; the usual temptation in regard to sewers, however, is to have them too large, when the rapidity of the flow of the sewage is diminished and waste lodges instead of being carried off.

In estimating the probable amount of sewage requiring disposal, the water-supply of a garrison may be considered as furnishing an amount of sewage of equal quantity. In opposition to the condition in a growing town, in a military post—the maximum strength of the garrison of which is known in advance—no allowance need be made for possible future growth in establishing the sewerage system. Where both the sewage and rainfall are carried off by a common conduit, the amount and character of the rains must be considered—violent storms taxing the sewers more than frequent gentle showers. The space occupied by the military population, because of the area from which storm-waters must be discharged, is of the much importance, and with a scattered population the difficulties of sewerage are much increased; the configuration of the surface and character of the soil also have much to do with the size of sewers, since a considerable portion of the rainfall sinks in a flat, sandy surface. The configuration may likewise cause engineering difficulties, while the existence of rock or sand may also prove to be an obstacle in respect to construction or permanence. It is evident that, with respect to the size of sewers, the question is so complicated where rain-water is disposed of by the same system that it is impossible to lay down any fixed rules, applicable to all conditions, with respect to the size of the main channel. The matter must be approached differently in each individual case, and with a full consideration of all the factors concerned. Having ascertained the maximum amount of sewage to be provided for, the size of the conduit and rate of flow can readily be determined.

Velocity of Flow in Sewers. — The force which removes sewage is gravitation, and this is enabled to exert its power by reason of the liquid condition of the sewage—for the solid constituents of the latter are relatively insignificant. The velocity of the stream in sewers is dependent not only upon their slope or fall but upon their shape, interior smoothness and even gradient, together with the volume and equability of the flow. The velocity also varies to some extent with the nature of the material to be carried and the facilities for flushing. The minimum velocity in sewers is at the bottom of the stream; it is upon this velocity that the scouring of the channel depends. Baldwin-Latham advises that sewers twelve to twenty-four inches in diameter should have a gradient sufficient to produce a velocity of not less than two and one-half feet per second. Rankin states that the velocity of flow in any sewer should not exceed four and one-half feet per second, and Rawlinson regards four feet per second as the greatest allowable velocity. A rate of six feet per second would be destructive to sewers; and probably the best rate of speed for conduits of

ordinary size is slightly more than half that figure. The question of allowing proper grade is of much importance; thus at Fort Ringgold an insufficient allowance in the original planning of the fall of the sewer has resulted in its repeated clogging.

As showing the scouring force possessed by various bottom-velocities in preventing the clogging of sewers, Beardmore states that the following rates of movement have the effect stated on the different materials particularized: 30 feet per minute will not disturb clay with sand and stones; 40 will move along coarse sand; 60 will move fine gravel, size of peas; 120 will move rounded pebbles one inch in diameter; 180 will move angular stones one and one-third inches in diameter.

Gradient of Sewers.—Sewers must be laid at a proper inclination, since otherwise obstruction will occur on the one hand, or a too great velocity of discharge will test the integrity of the sewer-pipe system on the other. For efficient action, small sewers require a greater inclination than large ones. To prevent deposit in sewers from six to nine inches in diameter, a velocity of not less than three feet per second should be secured; for sewers of twelve to twenty-four inches in diameter the velocity should not be less than two and one-half feet per second, and for larger sewers two feet per second. These velocities would require a fall of 1 in 140 to 1 in 200 for pipes six to nine inches in diameter; of 1 in 400 to 1 in 800 for pipes of twelve to twenty-four inches in diameter, and for larger sewers of 1 in 244 to 1 in 784, according to size. The fall should be equable, without sudden changes of level.

To show the inclination required to produce different velocities of flow in pipes of various calibers, Baldwin-Latham gives the following figures:

Diameter in inches.	Rate of Inclination for Velocity per Second.				
	Two feet.	Three feet.	Four feet.	Five feet.	Six feet.
4	1 in 194	1 in 92	1 in 53	1 in 34	1 in 24
6	1 " 292	1 " 137	1 " 80	1 " 51	1 " 36
8	1 " 389	1 " 183	1 " 106	1 " 69	1 " 48
9	1 " 437	1 " 206	1 " 119	1 " 77	1 " 54
10	1 " 486	1 " 229	1 " 133	1 " 86	1 " 60
12	1 " 583	1 " 275	1 " 159	1 " 103	1 " 72

For circular pipes, the following may be considered as the maximum allowable falls: Four-inch pipes, 1 in 36; six-inch pipe, 1 in 60; nine-inch pipe, 1 in 90. These estimates are based on the assumption that the pipes are running full or half-full.

Where sewage has to be carried down from a considerable height, the great difference in level constitutes no practical difficulty; since the internal pressure can be prevented from becoming excessive by the establishment of disconnecting manholes at frequent intervals.

Discharge from Sewers.—To calculate the discharge from sewers, Notter and Firth recommend the following formula:

$$V = 55 \times (\sqrt{D \times 2F})$$

In this, V = velocity in feet per minute; D = hydraulic mean depth in feet; F = fall in feet per mile. Then if A = section-area of current of fluid,

V A = discharge in cubic feet per minute. To use this formula, the hydraulic mean depth when the sewage is flowing, and the amount of fall in feet per mile, must be ascertained. The hydraulic mean depth is the section-area of the current of fluid divided by the wetted perimeter. In circular pipes it is always one-fourth the diameter; whether running full, half-full or otherwise. In egg-shaped sewers, the hydraulic mean depth varies with the amount of water flowing through them, but in sewers constructed on the usual plan, where the transverse diameter is two-thirds of the vertical, the hydraulic mean depth is as follows: Running full, transverse diameter × .2897; two-thirds full, transverse diameter × .3157; one-third full, transverse diameter × .2066.

The wetted perimeter is that part of the circumference of the pipe wetted by the fluid. In an egg-shaped sewer, under these three conditions, it equals the transverse diameter multiplied by 3.9649, 2.3941 and 1.3747 respectively. The fall in feet per mile is easily obtained, as the fall in one hundred or two hundred feet can easily be measured and the fall per mile calculated from this by dividing 5,280 by the denominator of the fraction.

Bailey-Denton has calculated the discharge from different sized pipes, running full at different velocities, as follows:

Diameter of pipe in inches.	Velocity three feet per second. Delivery in gallons per minute.	Velocity four and one-half feet per second. Delivery in gallons per minute.	Velocity six feet per second. Delivery in gallons per minute.
3	54	81	108
4	96	144	192
6	216	324	432
9	495	742.5	990

Sewer-air.—The rise and fall of sewage, with alternate wetting and drying of the walls of the conduit, favor putrefaction of organic deposits with the formation of gases—of the absence of which the fact that no foul odor is apparent is no proof.

Contrary to the opinion long entertained, sewer-air does not appear to be particularly hurtful to the organism, save in so far as it may favor the occurrence of disease through depression of the powers of vital resistance. A few instances of acute mephitic poisoning of an intense degree have been recorded; but usually the early symptoms resulting from the breathing of sewer-air are not especially marked. When the air of sewers penetrates into houses, and especially into bed-rooms, it may ultimately cause a greatly impaired state of health, especially in children. The latter lose appetite, become pale and languid, and suffer from diarrhœa; older persons suffer from headaches, malaise and feverishness; there is often some degree of anæmia and it is clear that the process of aëration of the blood is not perfectly carried on. In some cases, decided febrile attacks lasting three or four days, attended with great headache and anorexia, have been known. Houses into which there has been a continued escape of sewer-gas have been so notoriously unhealthy that no persons would live in them, and this has been not only from the prevalence of fever, but from other diseases also. Rawlinson mentions the fact that when the wind blew into the open mouths of the sewers of the military hospitals at Scutari, during the Crimean War, there was an accession of fever cases among the sick, and those

already existing took on a more aggravated type. There appears to be some relation between defective plumbing and outbreaks of typhoid fever and diphtheria, particularly the latter, but no direct proof of such a causal relation has as yet been adduced. It may be that the sewer-gases, by giving rise to a relaxed and unhealthy condition of the mucous membrane of the throat, may increase the liability to attack by diphtheria in the event of subsequent exposure to a specific infection.

In connection with the possible relation of sewer-air to specific diseases, some interesting experiments by Alessi are of value. This investigator noted the effect of the inhalation of sewer-air and the gases from putrefying materials upon animals—rats, rabbits and guinea-pigs being selected. After exposure to sewer-air, which was accomplished by placing the animals in a box with a perforated bottom communicating directly with a drain, each was inoculated with a small quantity of only a slightly virulent cultivation of the typhoid-fever bacillus; while other animals were similarly treated, except that they were not compelled to inhale sewer-air but were kept in their ordinary surroundings. Infected rats, after breathing this more or less foul air, began to lose their vivacity and after a time grew thin, although they ate voraciously; out of forty-nine which were inoculated with the enteric-fever bacillus, thirty-seven died, exhibiting the typical symptoms of enteric-fever infection. Of the forty-one rats, however, which although infected with enteric fever had not breathed sewer-air, only three succumbed. Thus the inspiration of drain-air had so far predisposed these animals to infection from enteric fever that a small dose of an almost harmless growth of this organism proved fatal to them. Guinea-pigs and rabbits, exposed in like manner to gases from materials in a condition of active decomposition, also acquired a predisposition to typhoid infection; for out of seventy-two guinea-pigs inoculated, fifty-seven died, while not one of those treated with the infective agent of enteric fever, under ordinary surroundings, succumbed. Similarly every one of eleven rabbits, treated and exposed to sewer-air, died, while not one of the inoculated animals lost its life when kept in fresh air. Alessi also found that the inhalation of gases from putrid substances enabled a small dose of a weakened culture of the bacillus coli communis, normally present in the intestine, to produce fatal results when purposely introduced into the animals thus exposed. He also ascertained that it was during the first two weeks of exposure to noxious gases that the animals were most easily predisposed to enteric-fever infection, for no less than ninety per cent. of all the animals inoculated during the first fortnight died, while seventy-six per cent. succumbed of those inoculated in the third week. This fact, Alessi states, may partly explain how it is that some people who habitually breathe contaminated air do not appear to suffer any evil results, having in course of time gradually become accustomed to it, while strangers exposed to the same conditions, without previous experience, may suffer very severely.

The air in sewers is in a constant state of movement from several causes. The movement of the sewage may cause a flow of air in the direction of its course, while, on the other hand, a strong wind blowing against the open mouth of a sewer may drive the contained air back with considerable force. Temperature is also an important factor in influencing the movement of air in sewers—its activity increasing with the difference in temper-

ature between the sewer-air and that outside. If at any time there is a rapid flow of water into a sewer, as in heavy rains, a bulk of air equal to that of the entering water must be displaced, this often occurring with great force. Out of which end of the drain the air passes, supposing the former to be unventilated, depends on force of circumstances. It moves readily in the line of least resistance, preferably in an upward direction as a result of the greater gravity of water. Under such circumstances, it is possible that the air-pressure in poorly constructed sewers might be sufficient to force a weak water-seal; ordinarily, however, sewers have numerous openings for communication with the outer air, and the internal pressure in sewers is thus rarely different from that of the external atmosphere.

The air in house-drains is often even more impure than that of the main sewers. This is the case also in other parts of the drainage system, and is to be accounted for by the numerous openings in the sewers, by the porosity of their walls, and by the amount of water in sewers being often so great and its flow so rapid as materially to lessen the deposit of sewage and the resulting generation of gases.

Ventilation and Disconnection of Sewers.—To avoid the dangers attendant upon the presence of a considerable proportion of sewer-gas in closed conduits, measures are taken to ensure its escape into the outer air and equalize the pressure within and without the pipes. This is commonly done by the use of man-holes or ventilating shafts, usually the former. These are put in at frequent intervals, particularly at points where tributary sewers join or where a sewer deviates from a straight course. Rawlinson considers that each main sewer should have an opening every hundred yards; but for ordinary post-sewers, the space between ventilating openings may be often several times this distance.

Man-holes are generally built of bricks, set in in cement; the drain being continued along the floor by half-channel pipes laid in the same substance. The cemented surface is raised several inches above the pipe, so as to prevent the sewage from overflowing. Ordinarily, gratings are used to protect man-holes; terminal man-holes particularly requiring an abundance of air. The use of pits at the bottom of man-holes, sometimes advised, is not to be recommended; since it favors the deposit of material which undergoes putrefaction and gives off offensive odors unless it is constantly being removed.

A sewer is disconnected when there is a large vent at the point of connection with a drain, either protected or not by a running-trap and water-seal. By this means the free ingress of fresh air or the exit of foul air, as the pressure may determine, is secured. In practice, this is not easy to carry out in snowy or very cold climates.

Care of Sewers.—The choking of sewers by deposits is brought about by any of the causes favoring sedimentation, such as original bad construction, too little fall, sharp curves, sinking of the floor, want of water or check of flow by tides. Such deposits may occur to some extent in well-made sewers. Even in those of so-called self-cleaning character, the changing level leaves a deposit on the walls, which, being alternately wet and dry, soon putrefies. In foul channels, a quantity of slimy matter often collects on the crown of the sewers, sometimes several inches in thickness and generally very offensive in character. Where rain-water en-

ters sewers it washes them thoroughly at times, but it also carries in a considerable amount of débris and gravel. If artificial flushing is required, this is usually accomplished in the military service by playing the fire-hose into it—an inefficient method—or by suddenly discharging the contents of a water-cart into the sewer. Where the quantity of water normally passing through the sewers is insufficient, it is sometimes advisable to hold the sewage back by gates until a sufficient quantity has collected to wash the entire channel by its sudden discharge; or tip-tanks are used for flushing, which discharge themselves when full. These arrangements are particularly necessary where a sufficient fall, to ensure a good flow, cannot be obtained in the sewer. Regular flushing is very important in keeping sewers clean, and where deposits cannot collect no foul gases are generated. Engineers are by no means agreed as to the quantity of water required for preventing deposits in sewers intended for the removal of excreta. Brunel regards twenty-five gallons per head per diem as the amount required to keep sewers clear, and with this he believes that there should be an occasional allowance for flushing; but in some cases a well-laid sewer and good fall require less, and in other cases bad gradients or curves require more.

Cleaning of sewers by other means than flushing has sometimes to be resorted to, notwithstanding the fact that theoretically they should be so constructed as to be self-cleansing. To facilitate this operation, man-holes, inspection-openings and cleansing-openings are provided. Deposits at such points can be removed directly, while the cleansing of the channel between these openings is accomplished by the use of brushes, wheels and scrapers on long jointed rods; or attached to a rope which has been carried through between two man-holes by means of a floating metal globe four inches smaller than the diameter of the circular sewer. The pressure of the flowing sewage under and around this globe, as it is carried through by the current, does much to scour out the channel and remove the softer deposits, while any firmer material is subsequently broken down by the scraper.

Local obstructions not rarely occur in the more poorly constructed sewer systems of our posts, as at Forts Ringgold and Huachuca, requiring forcible intermittent flushing or even frequent opening of the sewers to prevent clogging and remove obstructions. In several instances, as at Fort Baker, the roots of trees have forced their way through the joints of badly laid sewers, with resulting leakage and clogging.

The inspection of sewers is usually a matter of great difficulty, on account of the means of direct access being insufficient and the length of the sewers being great. A foul and clogged condition is commonly recognized by the presence of offensive odors and the damming back of the sewage into the afferent drains.

DRAINAGE AND PLUMBING.

Drains.—By the term drain is meant that conduit which intervenes between the waste and soil-pipes and the sewer, and which carries away the sewage of a single habitation. Like sewers, drains should be so constructed that there is no leakage, and should be air-tight save at points where ventilation is specially provided. Ventilation should be as free as

the safety of the water-seal permits. The drain may be of tile outside the building but should preferably be of cast iron, with caulked leaden joints or wrought-iron screw joints, and should be so located as to be readily accessible for inspection within the building. It is generally either hung on the cellar wall or suspended from the ceiling; if this disposition is impracticable, it may be laid in a cemented trench having a movable cover. Under ordinary circumstances, it should not be buried under the cellar flooring; if this appears to be absolutely necessary, the whole pipe may be embedded in concrete, so that any fracture will not result in leakage, and should be provided with an access opening at each end. Where a drain passes under the wall of a building, there should be a relieving arch or some suitable arrangement to prevent the pipe from being broken by settling of the foundation. Within the building, the drain should be provided with openings to permit of cleansing, these openings to be flush with the cellar floor and to be closed by brass sewer-plugs.

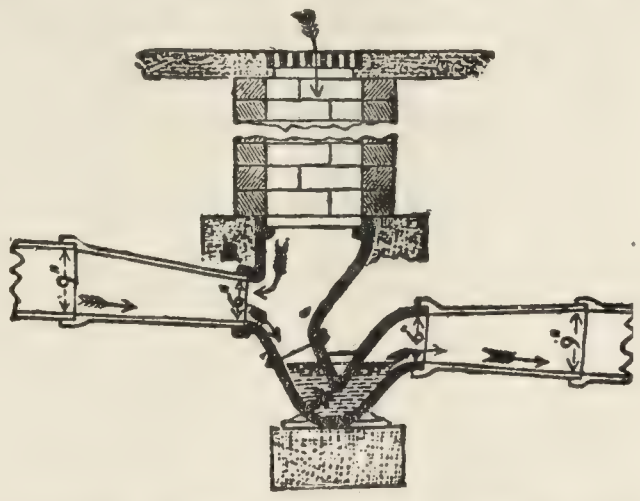


FIG. 263. — Section of Six-inch Siphon with Diminishing Pipe and Air-shaft. (Buchan's disconnecting and ventilating drain-pipe.)

Every house-drain should be trapped as near as practicable to its junction with the public sewer; an opening for ventilation being provided on the house side of the trap and the building and sewer being thus completely disconnected. The drain-trap should be a running or half-S trap, and should be placed so as to be readily accessible. The drain-pipe should be capable of being opened for cleansing purposes by an access-pipe beyond the water-seal. Buchan's ventilating and disconnecting trap is much used for the disconnection of drains. Some authorities, however, are opposed to the drain-trap and favor a free and unobstructed vent from the sewer to the roof, furnished by the drain and its ventilating pipe.

The inclination at which house-drains are laid depends upon the velocity of the current desired. This should be sufficient to secure efficient scouring of the channel without special flushing; but, on the other hand, the inclination should not be so great as to allow the liquid portions to flow away, leaving the solid matters behind. While the fall to be given a drain must be decided according to the special circumstances of each case, it may be taken as a general rule that the average house-drain should have a fall in about one in fifty. Maguire gives the following rule for determining the necessary grade: Multiply the diameter of the drain in inches by ten; thus a four-inch drain should have a fall of one in forty, a six-inch drain of one in sixty, and so on. These estimates are based on the supposition that the drain will run half-full. When running full, the discharge is of course doubled, but the velocity and scouring force have no further increase. Where the current is feeble or the fall insufficient, an automatic flush-tank may be placed at the upper end of the drain. With respect to the size of the drain, one of six inches in diameter will suffice for the needs of a company barrack and is more readily kept free from deposit than one of larger size. In the drainage of barracks it is customary to put access-plugs at each angle of the pipe, to facilitate the removal of clogging material.

The junction of pipes with drains, and of drains with sewers, should always be made at acute angles, since otherwise stoppage is liable to result. Like sewers, drains are usually cleaned outside the building by means of man-holes, through which these wage flows in half-round pipes. Within the building, access-pipes are used for this purpose. The use of movable caps, sometimes advised, is of no advantage under such circumstances; and leakage is liable to occur after the cap has once been removed. Drain pipes should be regularly flushed, and cleaned when necessary. The latter is generally done by flexible bamboo or jointed rods, provided with screws and rollers to loosen the sediment. With straight drains, obstructions are of course more easily detected and removed. The stoppage of drains may be noted by throwing milk of lime into a sink or closet and watching for its appearance in the man-hole disconnecting the house-drain and sewer.

The spouts for the conduction of rain-water from roofs should discharge in the open air over trapped gratings having a catch-box for gravel. Sometimes these rain-leaders have opened directly into the drain, as at Fort Bayard, and acted as ventilators for the latter—the foul air being thus often conducted to the vicinity of windows. All waste-pipes and overflow-pipes should terminate in the open air like rain-leaders, and be thus cut off from direct communication with drains.

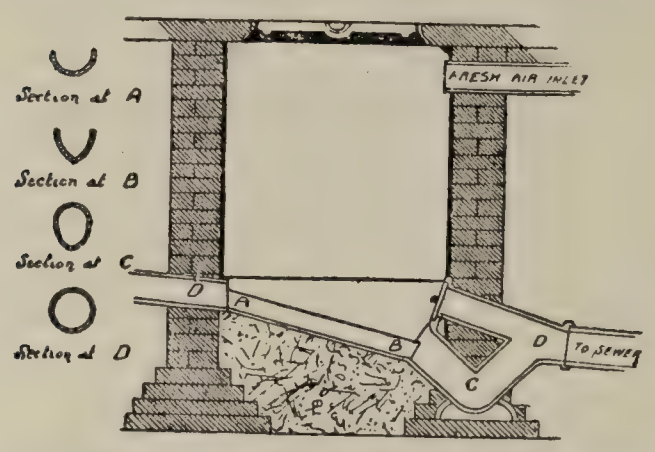


FIG. 264.—Disconnecting Chamber, in Longitudinal Section.

Soil-Pipes. — The soil-pipe receives the discharges from water-closets and conducts them to the drain. All things considered, wrought-iron screw-jointed pipes are probably the best for this purpose, thus avoiding any leaky jointing. Drawn-lead pipes are excellent, but are both costly and heavy; seamed-lead pipes should not be used. Cast-iron pipes are cheaper, but they must be strong and have their inner surface as smooth as possible. Castings are not rarely of uneven thickness; and, as with a rope, the strength of a line of piping is its weakest point. Where air-bubbles are present to weaken the material, the strength of the pipes may be tested by sharp hammering. To give a smooth inside finish and prevent rusting, iron pipes are sometimes given special treatment. Angus Smith's process consists in dipping the clean pipe into a bath of coal tar, pitch and linseed oil, heated to a temperature of 400° F. The Barff process consists in producing a coating of black oxide of iron by exposing the clean pipe for eight or ten hours to a temperature of 1,200° F. in an atmosphere of super-heated steam. The use of artificially coated pipes is, however, being discontinued. All junctions in the soil-pipe must be solidly made. Cast-iron pipes are joined by pouring molten lead into the sockets when the lengths are in position, a small packing of oakum having previously been introduced to prevent the liquid metal from penetrating to the inside of the pipe; when cold, the lead is driven home with a caulking iron. Lead is joined to iron by tipping the leaden pipe with a brass ferrule, which is afterward caulked into the iron with melted lead. Where lead pipes are made to connect with earthenware closets, the joint is usually made tight by the use of red lead. Throughout the installation

of the soil-pipe, every joint should be made with a view to its being tested under hydraulic pressure. Particularly where the whole circumference of the pipe is not easily accessible, this test will often reveal serious leakage around caulked joints.

The descent of the soil-pipe should be as direct as possible, and when carried laterally the pipe should have a decided grade with but few turns. Where such turns are necessary, they should be as gradual as possible. The water-closet pipe should join the soil-pipe at an acute angle, and by as short a length of pipe as possible. The outlet of the soil-pipe should be full bore and should join the main drain at an acute angle. Provision should be made so that the pipe can be opened at this point for inspection and cleaning, since it is particularly at this junction that obstruction is liable to occur. For company barracks, soil-pipe four inches in diameter is of sufficient size. The pipe itself should be carried up full bore above the roof, terminating away from all windows or chimneys. Sometimes an upcast ventilating cowl is placed over the open top; Waring, however, prefers to use no cowl but to make the top of the soil-pipe flare slightly. In hot climates, soil-pipes should be protected against the direct rays of the sun, so as to avoid their becoming bent or their joints from opening from expansion.

However carefully the soil and drain-pipe system is constructed, a certain amount of sliming of its walls is unavoidable; the putrefaction of such adherent material giving rise to dangerous and offensive gases. These should be removed by ventilation, which requires two openings for its efficient action. The latter are secured by extending the soil-pipe through the roof, with a vent of full size communicating with it by a branch pipe outside the house. This arrangement, from the greater warmth of the house, creates a constant current of pure air through the soil-pipe. When the closet is used, the current of air is of course reversed, as a result of the passage of the water downward through the pipe. If the water-seal of the closet should fail from any cause, by this arrangement fairly pure air and not sewer-gas would escape into the building, and thus the danger from accidentally unsealed traps is materially lessened. Where the drain is long, it is sometimes advisable to place a disconnecting trap and water-seal close to the building, so that the air circulating in the soil-pipe may be as free from sewer-gas as possible. By this arrangement, also, back-pressure against the water-seals of interior traps, either through the production of gases by putrefaction or by a forcible and sudden flushing of water, is thus prevented.

Traps.—It is highly important to prevent the entrance into habitations of air from pipes soiled with excreta or waste-water; a result sure to occur unless means are taken to prevent the aspiration of the foul air into the building by reason of the greater warmth of the latter. Experience has shown that simple water-seals afford the most efficient means of excluding such sewer-gas; all mechanical devices for this purpose, such as valves, balls and plungers, being uncertain in action and hence unsatisfactory. To provide an efficient barrier against the passage of air, a depth of water of at least three-fourths of an inch, standing above the highest level of water in the curve of the trap, should be provided. It is true that sewer-gas dissolves in water to some extent; but as the supply in the

traps is frequently renewed, this need cause no inconvenience in practice. All fixtures should be so trapped that while exclusion of foul air is assured, at the same time all filth shall be immediately carried away by flushing and the trap refilled with fresh water. Every portion of a trap should be scoured out with each flush, but this thoroughness of action by no means necessarily involves any waste of water. Many traps are so constructed, as the mid-feather and D-traps, that no amount or velocity of water can clean them. The inner surface of water-closet traps should be perfectly smooth, with no projecting portions to retain filth—which implies their construction of earthenware or enamelled iron. The general disadvantages of traps are that they furnish a check to the flow of water through the pipes and an obstacle to the escape of solids. In special instances, traps are ineffective by means of bad laying, fouling from use, insufficient flushing and loss of the water-seal.

The factors tending to destroy water-seals are: Siphonage, back-pressure, evaporation, capillary action, accumulation of sediment and leakage. The first three depend on the action of the surrounding atmosphere—the last three have relation to the character of the trap and the nature of the substances which enter into it.

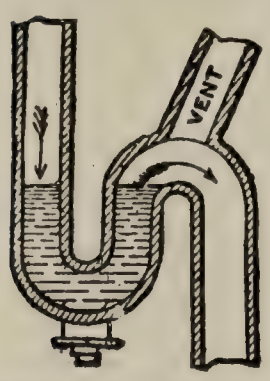


FIG. 265. — Vented Trap.

Siphonage results from the action of a heavy column of water falling down a soil-pipe from one fixture and thus producing a partial vacuum, as a result of which the equilibrium of the seal in another fixture is broken by atmospheric pressure within the closet. Trap-siphonage may also depend upon the rapid discharge of water through an unvented closet-pipe, where the seal may be broken by the sheer momentum of the mass of escaping water. Small pipes and shallow water-seals are much more liable to siphonage than are large pipes and deep seals. Where two siphons succeed each other in the same pipe, without a sufficient connection with the outer air between them, the lower siphon will suck the other dry. Back-pressure results from the descent of a heavy column of water in a main soil-pipe to near its end, where there is an abrupt bend or some other obstacle to the escape of the air which has been compressed in front of it. The latter, moving in the direction of least resistance, may pass up a branch pipe and force the water-seal. To produce back-pressure, the descending column of water must have acquired considerable velocity and there must be an impediment to the escape of air before it. The fixture whose trap is forced will therefore be near the bottom of the soil-pipe. The pressure of sewer-gas by itself will rarely be sufficient to force a water-seal. Back-pressure and siphonage are complementary and both cannot occur in the same fixture.

Both back-pressure and siphonage may be avoided by equalizing the air-pressure within and without the pipe, by venting the latter in the top of the bend by a pipe which opens into the outside air or into a general vent-pipe. The vent-pipe should have the same diameter as that of the trap-pipe, since the object of such venting may be readily defeated if the pipe be so small that the necessary amount of air cannot be admitted in a given time. Sometimes the same result is brought about by clogging of the vent-opening from the accumulation of waste matters washed into it during the use

of the trap. Friction also must be considered in this connection and the vent-pipe should thus be as short and straight as possible, for the resistance produced by the walls of a long, narrow and perhaps tortuous channel may be a greater obstruction than the inertia of a light body of water in the trap. On the other hand, too free access of air greatly increases the liability to loss of the water-seal from evaporation. Where vent-pipes are used with a number of traps, they are usually made to unite in a single ventilating pipe, which may end above the roof like the soil-pipe or open into the latter at a point just above the highest fixture.

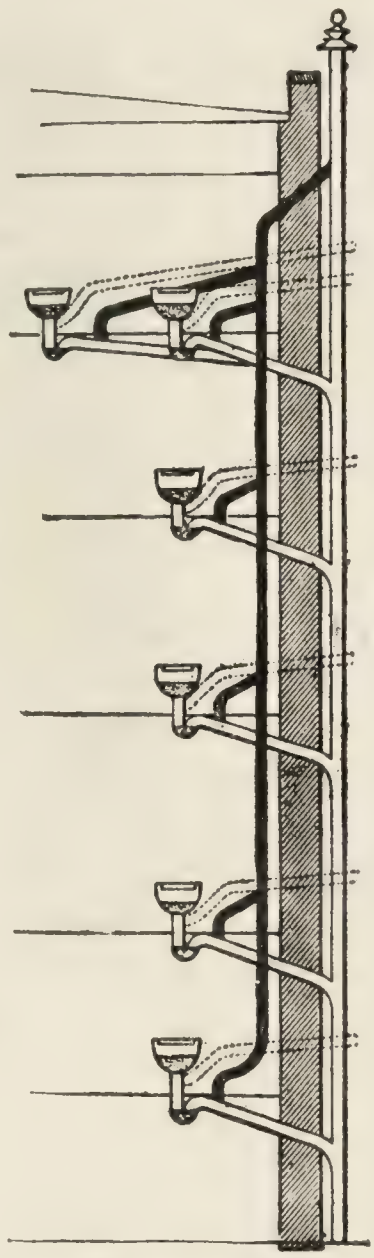


FIG. 266.—Method of Connecting Water-closets with Soil-pipe, together with Venting of Traps.

The seals of traps are often broken as a result of evaporation; the rapidity of the process varying with the temperature and movement of air over the water surfaces. As just mentioned, the process of evaporation is greatly accelerated by the use of vent-pipes—and such a vent has been shown sometimes to destroy a water-seal through evaporation in less than a week. To overcome this fault of vent-pipes and still avoid the dangers of siphonage, special devices have been put on the market. Among these, the "Sanitas trap" gives excellent results. In this apparatus, a projecting reservoir having an inside protection of fine wire-gauze is screwed into the farther arm of an S-trap at about the height of the water level. As water and excreta are flushed through the trap, reverse currents are formed by which the side reservoir is filled with fluid while the solids are carried off through the escape-pipe. As soon as all the water in the trap has been discharged, the bend in the trap is refilled by the water which runs out of the reservoir as soon as the pressure is relaxed. As the reservoir of this trap ultimately collects a certain amount of solid material, the former, usually made of heavy glass, should be unscrewed from time to time to permit of cleansing.



FIG. 267.—"Sanitas" Non-Vented Trap.

Traps are occasionally emptied of their water by capillary action; which results where a rag or bit of string has one end passed up over the further bend of the trap, while the other end is immersed in the liquid. The water in the trap is rapidly removed under such conditions.

Unsealing of its water-trap is sure to occur if a fixture remains unused for a certain length of time, this depending on the warmth of the weather or room and on the depth of the water in the trap. Hence vacant barracks and quarters should be given attention in this respect, since where the seal is broken the building is soon filled with sewer-gases. This is especially important in the case of double quarters or barracks, since neglect

of this kind in one set affects the sanitary condition of the adjoining quarters. Where buildings are to be long vacated, and periodic flushing of the traps cannot be relied upon, the water-seals can be prevented from being destroyed by pouring a little oil into the fixtures. The back part of the seal is protected in the same way, the oil being passed in through a curved pipe beyond the bend in the trap.

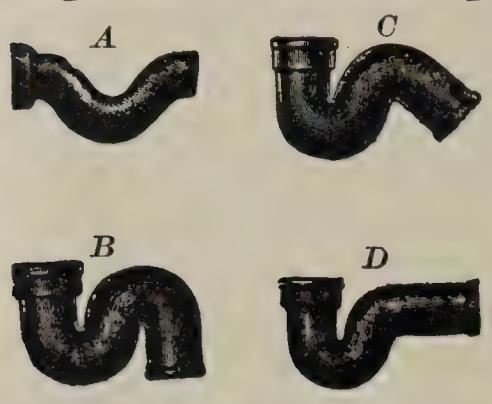


FIG. 268.—*A*, Running trap; *B*, S-trap; *C*, three-quarter S-trap; *D*, half S-trap.

A temporary obstruction in an ordinary siphon water-closet trap may be cleared away by making up a soft swab on the end of a stick, so that the whole shall have a diameter about equal to the bore of the siphon, and working it up and down like a piston after the trap has been filled with water. Obstructions of a fairly soft nature are thus readily expelled and forced into the soil-pipe. An examining eye is often put in siphon traps to facilitate cleansing; but when this is located over the bend, clogging results and the flow is retarded.

Traps are made in an almost infinite variety of forms, but nearly all those now employed are made by bending an ordinary pipe to a greater or less extent, so that a body of water completely closes off the lumen of the pipe. Traps of this character are not only the most simple but also the most satisfactory. The common forms are the running trap—a shallow bend in a nearly horizontal pipe—the S, half-S and three-fourths S. Sometimes these bends are enlarged so as to prevent siphonage, but such pot-traps collect much solid material and practically become nothing but small cess-pools. The ordinary running-trap is sometimes made with two openings beside the inlet and outlet, by which cleansing of the further side of the trap and ventilation of the hither side may be secured. This trap usually has a flat external bottom which ensures its being laid level. Buchan's trap merely has an access-pipe for cleaning the drain beyond the water-seal. The sewage enters the trap with considerable fall, so that the latter is flushed clean.

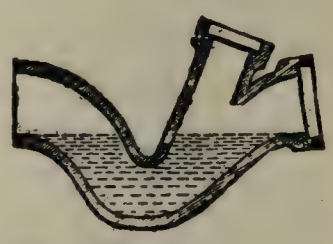


FIG. 269.—Buchan's Trap.

Mechanical devices have sometimes been used to increase the efficiency of a water-seal or guard against its loss. Thus in Bowers' trap a rubber ball is buoyed by the water against the mouth of the pipe leading from the fixture. The discharge, in passing, temporarily displaces it; but it immediately resumes its guard, closing the aperture so long as sufficient water remains to float it into position. Mechanical closures of traps, whatever their character, are not only wholly superfluous but dangerous, since opportunity is afforded for the lodgment of filth and the proper operation of the trap, after this has occurred, cannot always be ensured.

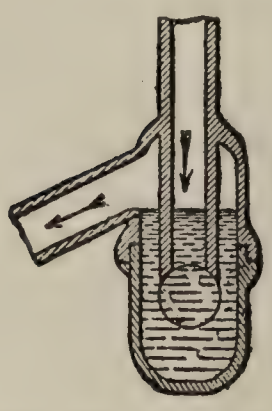


FIG. 270.—Bowers' Trap.

Another bad form of trap, which requires special notice because some of this pattern are still in use in our service, is the D-trap. In this apparatus there is a large surface which becomes coated with filth and generates foul air. The trap is generally rectangular in section, and has many sharp angles, projections and recesses by which the deposit of filth is favored.

The mid-feather or dip-trap, sometimes used in connection with drains, is merely a box having an entry at one side and a discharge pipe at the other, with between them a partition reaching below the level of the pipes, so that its lower edge is always to some extent under water. The trap is not self-cleansing, and heavy substances subside and collect in the box. Its disadvantages are obvious.

Somewhat analogous to this trap, the flap-trap is sometimes used; it possessing a hinged valve which allows water to pass in one direction, but which is so hung as to allow it to close by its own weight. It is intended to prevent reflux of water from sewers into the secondary drains, and is also supposed to prevent the passage of sewer-gas, for which purpose it is a very imperfect safeguard.

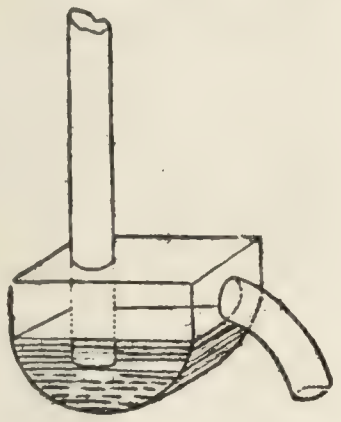


FIG. 271.—D-Trap. (After Notter and Firth.)

The ordinary form of gully-trap is a very simple and efficient apparatus so far as the drainage of yard and rain-water pipes is concerned. It is intended to retain sand, gravel and other heavy material which may be carried in by the water and thus prevent clogging of the pipes. It is essential that the catch-basin be periodically cleaned out and any deposits removed. To facilitate this, a bucket with a lifting handle is sometimes made to fit accurately in the reservoir of the trap.

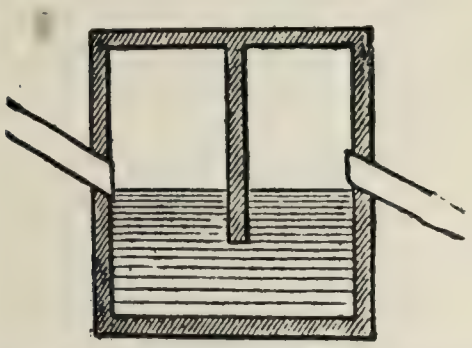


FIG. 272.—Mid-feather Trap. (After Notter and Firth.)

Areas on which water may accumulate are often drained by the use of the bell-trap. In this apparatus, a perforated metal plate permits the water to enter a basin which lies underneath it, and when this water rises to a certain height it overflows into a central pipe which carries it into the drain. A hemispherical cup attached by its bottom to the under surface of the plate makes a loosely-fitting cover for the mouth of the pipe, and, by dipping into the water contained in the basin, prevents the escape of emanations from the drain. This form of trap is very defective from a sanitary standpoint and should not be used. It is unsealed whenever the bell cover is left off and the small quantity of water which forms the water-seal soon evaporates. In order to hasten the flow of water through the discharge pipe, the cover is frequently removed, leaving the waste pipe untrapped. The bell is also easily broken off from the perforated plate, in which case the seal is destroyed and sewer-gas escapes.

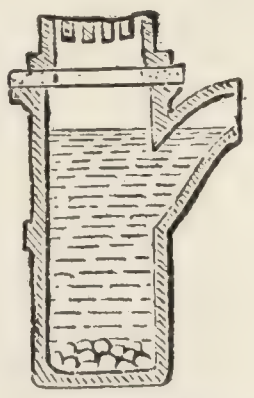


FIG. 273.—Common Gully Trap. (After Notter and Firth.)

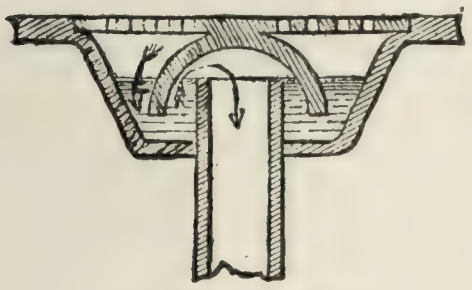


FIG. 274.—Bell Trap.

Testing of Plumbing.—"Sanitary engineers consider that an unusual smell is generally the first evidence of something wrong, and that when this is traced to its source the evil is half cured. If the basement smells generally offensive, a leaking drain-pipe, badly jointed or broken by settlement, may be searched for, and where this has been improperly laid the leaky drain may show itself in dampness

of the paving or soil in its vicinity. If rats are often seen, the drain is probably in direct communication with the sewer, and the presence and condition of traps should be ascertained. Where a smell arises from a particular sink or trap, it is evident that there is no ventilation of the drain, or at least no trap at the entrance of the drain into the sewer. Where cess-pools are in use, such odors generally mean that they are unventilated. Traps full of foul black water, impregnated with sewer-gas, often emit foul odors. These odors can generally be removed by flushing, but the character of the trap as regards its self-cleansing properties should be ascertained. Where odors are noticed on upper floors in quarters, they may be due to an untrapped or defective closet, a leaky soil-pipe or its improper connection with the drain below. Where smells are only occasional and occur during flushing, it is probable that the odors are due to lack of trapping in the hopper or closet-pipe. A slight escape of impure air from drains may be difficult to detect, and the odors may be attributed to deficient ventilation. Where the drain system has been treated with strong-smelling disinfectants, inspectors obviously cannot detect sewer odors. As already noted, smells from drains are not necessarily of a foul nature, and a close, sweet smell may often be detected."

In testing pipes and traps, the cover and skirting boards should be removed; all underground pipes and traps should preferably be laid bare and every joint and bend examined. If this cannot be done, the following measures may be tried: Let water run down the pipe and observe whether there is any smell. Should there be, the pipe is either full of foul air and requires ventilation or the trap is bad. If a lighted candle or piece of smouldering paper be held over the entrance of the pipe, a reflux of air may be found with or without water being poured down. It should also be noted whether the water runs away freely at once or if there is any check to its flow. From this, the clogging of the trap or pipe may be inferred.

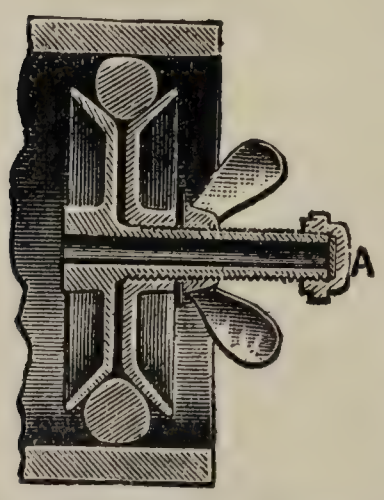


FIG. 275.—Sectional View of Drain-plug in Position.

Suspected leaks are searched for by water, smoke or some pungent chemical. Of these methods, the test by water is best, since it reveals cracks which may be filled up by the thin coat of paint given the pipe on leaving the foundry. The test is very severe, but is certain in its results. It is performed by plugging the pipe and filling it with water until the latter reaches the level of one of the traps—any subsidence in the level of the water denoting a leak. For the best results in practice, a special plug is employed. This consists of two galvanized-iron discs between which is a rubber ring; on tightening these discs by means of a thumb-screw, the rubber ring is expanded against the walls of the pipe, making an air-tight joint. To remove the plug, the cap *A* of the hollow bolt is removed, so that the water can escape gradually and without swamping the operator. Where there is considerable pressure, the plug should be held in place by a piece of timber, to avoid its being forced out during the operation. Different-sized plugs are of course required for pipes of different diameters. For this test, no great head of water is required—not more than two feet. If leaks appear at all, they usually

occur with a few inches pressure and always under that of a few feet. If after one or two hours there is no change in the level of the water, the pipe system concerned may be considered sound. No quartermaster should accept and pay for plumbing until the waste-pipe system has been thoroughly tested by water; experience showing that joints found to be originally tight rarely develop leaks subsequently.

Sometimes a drain of doubtful tightness is filled with smoke by the use of a smudge-and-bellows apparatus, when the situation of a leak will be shown by the appearance of the smoke. Smoke-rockets have also been used for this purpose, but the smoke test, as a whole, may be regarded as least satisfactory of the several named.

A simple method for the detection of leaks consists in the use of oil of peppermint; an ounce of this in a few gallons of hot water being poured down the pipe at its highest point. As this oil is very volatile, there is no difficulty in locating any leak by the odor. In making this test, too much care cannot be taken, and at least ten minutes should be allowed between pouring in the oil and beginning the search, so that the odor may penetrate to every part of the system of piping. In searching with peppermint, all ventilating openings should be temporarily stopped up, and the one who uses the oil must remain at his post while another searches for the leaks.

Sanitary inspectors now largely use glass grenades charged with oil of peppermint or other pungent chemicals. One of these is sometimes wrapped in a piece of tissue paper, broken in the fingers and dropped into the trap, through which it is at once washed by a bucket of water. The paper becomes saturated and allows the scent to circulate through the pipes. A better arrangement consists in placing the grenade in the receiver of the patent exploring-apparatus, as shown in Fig. 276. This is passed through the water-seal under the dip of the trap, when its buoyancy will float it to the drain side of the latter. The cord attached to the apparatus is made fast, giving two or three feet of play, and a bucket of warm water is poured suddenly into the trap, which washes the apparatus into the pipe. The line is given a slight jerk as it tightens, which breaks the grenade and allows its pungent contents to be discharged. The apparatus is allowed to remain *in situ* while the test is being continued, since on removal it is necessarily somewhat impregnated with the odor of the chemical employed.



FIG. 276.

General Considerations.—In respect to plumbing and drainage, even more than in any other department of building, it is essential that only sound and durable materials be used. It would seem superfluous to call attention to this point, did not the too frequent presence in military posts of cheap apparatus, poor material and bad workmanship, installed under a more economical administration, show the necessity for such action. It must be repeated that in the military service no makeshift appliances as regards drainage or sewerage should be allowed. No emergency is to be met when a sewerage system is installed, and no excuse is thus furnished for the employment of improvised apparatus.

In a plumbing system the essentials are: A sound water-seal, immedi-

ate and complete removal of waste, complete ventilation, thorough and frequent flushing, soundness and durability, tightness as regards air and water, economy of construction and operation, automatic and noiseless operation. In general, the amount of plumbing should be reduced to the lowest possible limit; while the cardinal point of simplicity is always to be kept in mind. The entire arrangement should be directly visible and accessible from end to end, whence it follows that the closing in of plumbing with wood should be avoided. Where the closet fixture is boxed in, the enclosed space serves as a receptacle for dust and dirt, while droppings from careless usage get inside the wood-work and develop bad odors. These odors increase with time, since access to their cause by the great natural purifiers, light and air, is prevented. In addition, plumbing should not be located against an outer wall in cold climates, since this arrangement greatly increases the danger of freezing. The mere recapitulation of these points shows the many practical difficulties to be met with in plumbing, and shows the necessity for careful forethought and intelligent supervision in its installation. It is not sufficient for a quartermaster to assume that because a contract has been made to introduce fixtures all that is necessary has been done, nor does it always follow when plumbing is complained of that a broken pipe or leaky joint is the only imperfection.

Besides the provision of barrack latrines and water-closets for officers' quarters, it is essential that the habitations of enlisted men be provided with sanitary plumbing and drainage, not only for the greater comfort and welfare of their occupants, but also because of the manner in which unsanitary conditions anywhere in the post react upon the health of the garrison at large. In the absence of drainage and sewerage, the most unsanitary conditions in a post, with respect to the disposal of excreta and liquid waste, are generally to be found in connection with married soldiers' quarters.

WATER-CLOSETS AND WATER-CLOSET APPARATUS.

Location and Arrangement of Water-Closet Latrines.—This subject is one of much importance to the military sanitarian, since improperly located latrines and poorly installed fixtures may be a cause of grave insalubrity. The latter point is of special importance in our service, in which the latrines are too frequently in the same buildings in which the men live, sleep and eat; while in many foreign armies, as in those of Great Britain, France and Germany, the latrines are located in special detached buildings, between which and the barracks there is complete atmospheric severance. Of the two arrangements, the latter is much to be preferred. It may be improved, however, by the addition of an airy corridor, through which the latrine may be reached from the barrack by the soldier without exposure during stormy or inclement weather. This separate latrine-building should be located to leeward of the barrack, and at a distance sufficient to prevent any nuisance from arising through its use, yet sufficiently close to be easy of access. In our own service, a combined lavatory, bath-house, water-closet and urinal, in a detached building, has recently been approved for use in small posts, particularly those in connection with coast defences. The arrangement, shown in the accom-

panying illustration, is somewhat crowded and is not free from other criticisms, but it represents an endeavor to accomplish as much as possible with a limited appropriation and is a marked sanitary improvement over the plan of putting the conveniences in the barrack-building proper. This detached structure is intended to meet the needs of one hundred men.

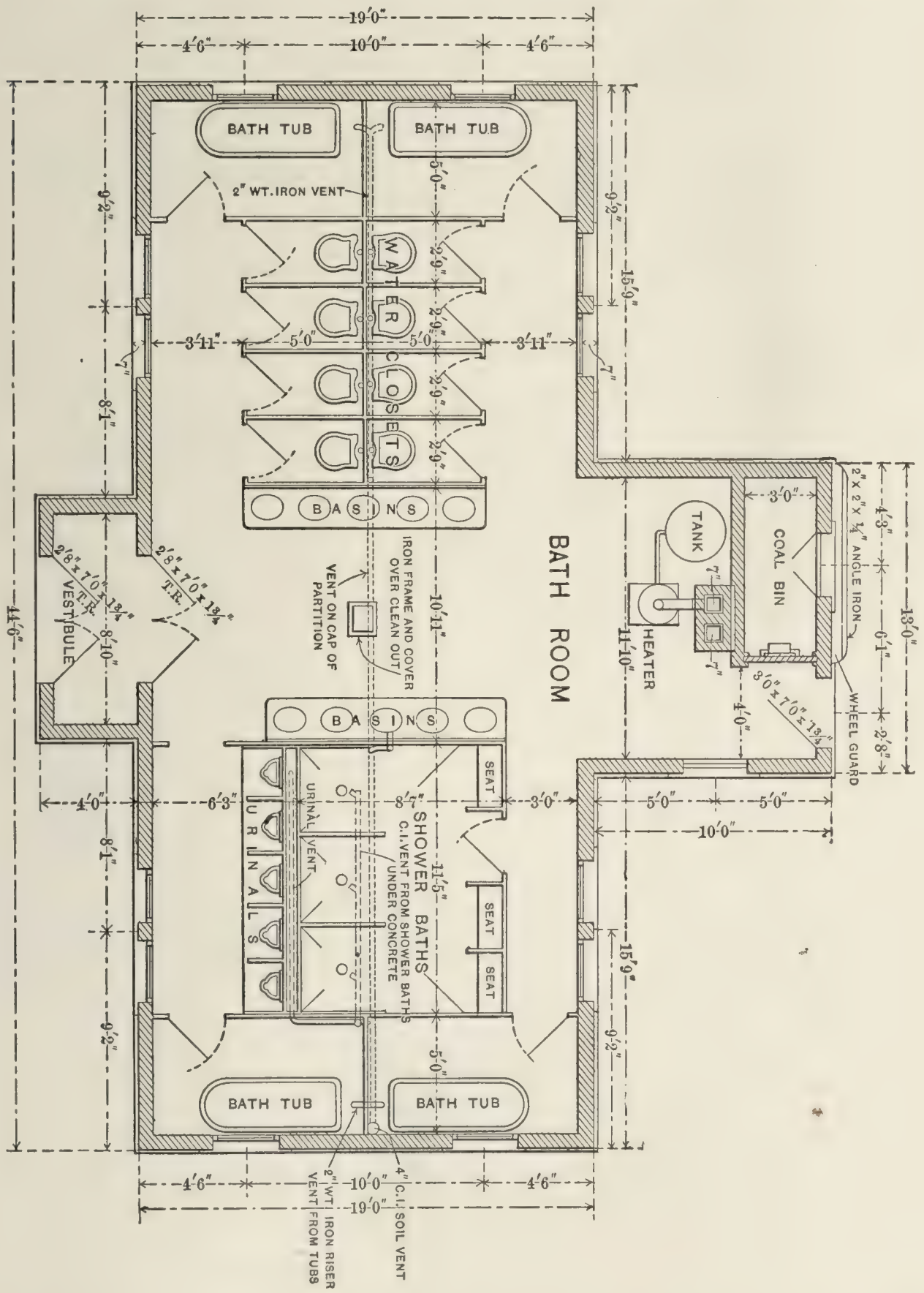


FIG. 277.—Plan of Detached Combination Lavatory, Bath-house, Urinal and Latrine for One Company.

In the majority of barracks of more recent construction, where water-carriage is employed for the removal of waste, the latrine and lavatory fixtures are placed in the basement of the building. This arrangement, as just noted, is undesirable from a sanitary standpoint, although more economical; wherever it is employed, at least the space utilized for this purpose should have three outside walls, so as to permit the entrance of as much fresh air and sunlight as possible. This is a simple sanitary matter

which can always receive consideration in the planning of barracks, yet one which has unfortunately not been always considered in later plans. A type of this less desirable arrangement is seen in the accompanying plan of the barracks lately constructed; in which the row of water-closet seats is placed against a dead inside wall, and light and air have access on two sides only. The installation of lavatory and water-closet con-

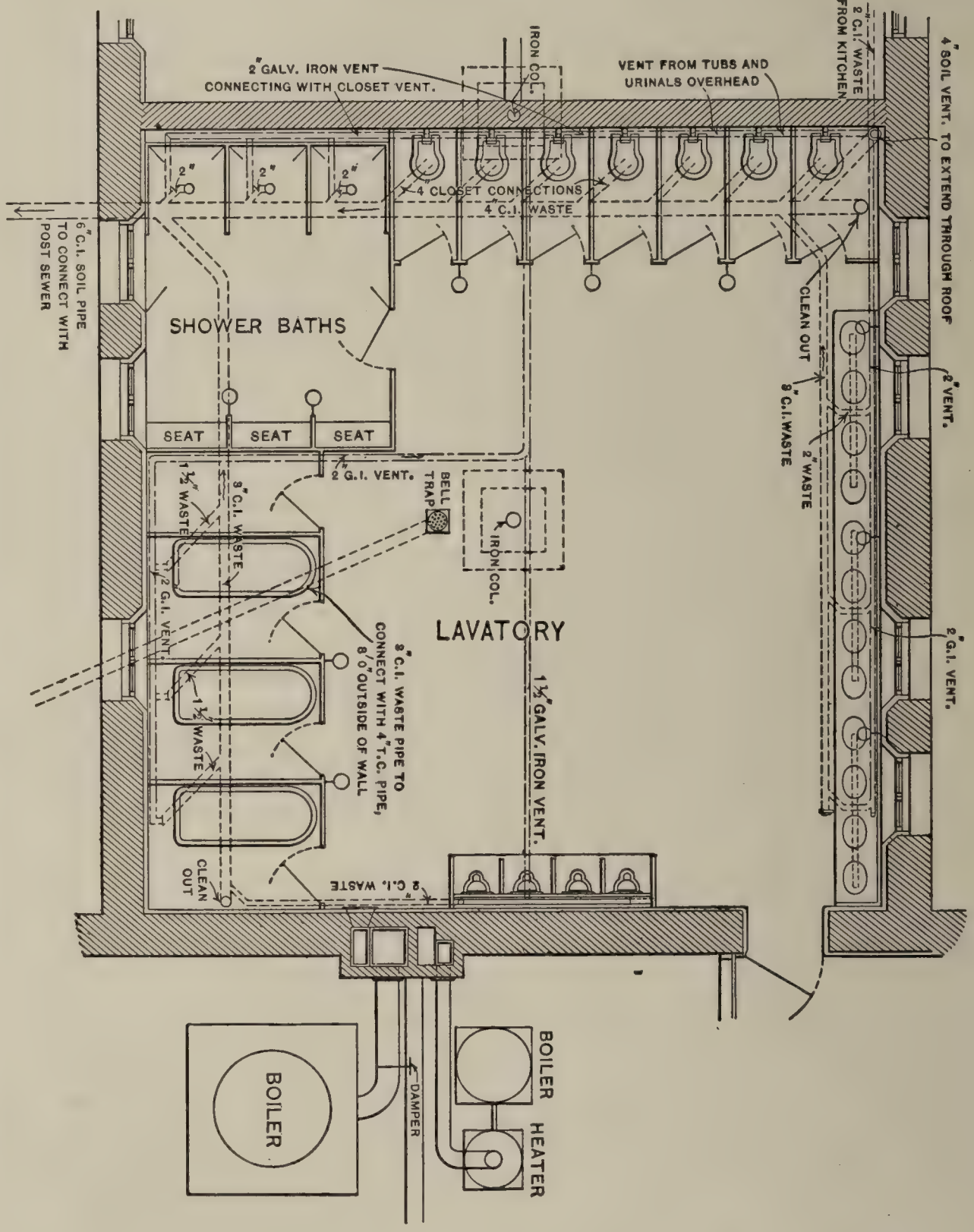


FIG. 278.—Plan of Combination Lavatory, Bath-room, Urinal and Latrine, Located in Basement of Company Barrack.

veniences in casemates, as has been done at Forts Warren, Adams and other sea-coast fortifications, should be prohibited, and such fixtures as are already in position should be removed and placed in special buildings erected for this purpose. Casemates used under such conditions are always damp, foul-smelling and badly ventilated. The free opening up of latrines to light and air should be insisted on.

The materials used for the construction of latrines should be such as are solid and impermeable. In the French army, brick and corrugated iron are solely employed for such purposes, the angles of the walls being rounded

and the walls and floors being impervious to moisture. Wooden floors should never be used in latrines, but cement or some similar non-absorbent material is to be employed. The windows in the latrine should extend to the ceiling, and the building or space should be efficiently ventilated. Comparative privacy should be afforded by stalls having louvred partitions, and if the rows of seats face each other there should be a movable screen four or five feet high between them. Doors should not be used with these stalls, as they are liable to become dirty and contaminated with fæcal matter. All partitions should be no more than six feet in height and should be cut away for the distance of a foot above the floor, so as to permit the free circulation of air and more ready cleansing. In winter, such latrine closets must be heated; not only for the comfort of their visitors, but also to prevent injury to the plumbing fixtures through freezing. An abundant supply of water should be available, while the fixtures and plumbing should be of the simplest character. All latrines should be provided with lavatory facilities, so that washing of the hands may be practicable. It should not be forgotten that unless latrines are convenient and comfortable, the men will put off resorting to them as long as possible, thus favoring the production of constipation with its train of evils.

With respect to the capacity of the latrines to be provided, regulations for the British army require that there shall be five latrine seats and five urinals for each hundred men. This is certainly the bare minimum required. While there is no standard in this respect for our service, it is customary to install seven or eight water-closets and four or five urinals to each company of one hundred men. The allowance of latrine-seats in the French and German garrisons is much lower than in our own service. The evils of an insufficient allowance in this respect are obvious.

Night-Latrines.—In the French and British armies, where the latrines intended to receive the excreta passed during the day are located in detached structures, special provision is made for the disposal of such as may be passed during the night. Detached latrines are regarded as being a possible source of disease through the exposure involved in their use by partially-clad soldiers at night, and a circular issued in the French army, in 1895, called attention to the greater liability to bronchitis, pneumonia and rheumatism which it was thought resulted from such exposure. For this reason, it is required that one urinal and one water-closet are to be provided in the barracks of each company for night use; in the British army, no means for the disposal of the solid excreta are provided in barracks, but each squad-room has a night-urinal directly connected with it. These night-latrines and urinals are kept locked during the day.

Where water-carriage is not available, urine-tubs and dry-earth closets or close-stools are used in the British and French armies. These are removed at reveille and replaced at night. They are generally located in well-ventilated rooms or in projecting closets built out from the main barrack-building for this purpose.

Night-latrines are of course unnecessary where the water-closets and urinals are situated in the barracks. If properly located in detached structures connected with the barracks by covered passage-ways, the latter can be closed in at the sides by movable sashes during night time or inclement weather.

Water-Closet Fixtures.—In the selection and installation of water-closet fixtures for use in military posts, it is to be borne in mind that the apparatus should be simple and solid in construction and easy in respect to operation and the maintenance of cleanliness. Apparatus of complicated character, or such as appears liable to be readily broken or get out of order, should be rejected at the outset, and the same also applies to fixtures the efficient operation of which requires special care or which is directly dependent upon human intervention. The force and volume of water supplied should be sufficient to sweep everything out of the receiving basin and maintain its cleanliness, while the shape and capacity of the latter should be such as to allow the excreta to fall free of the sides and directly into water of such depth as to cover the discharges. In general, a good type of water-closet is limited to such patterns as have a free water-way from the bowl to the soil-pipe, depending for their trapping and the retention of the necessary water on the elevation of the overflow point.

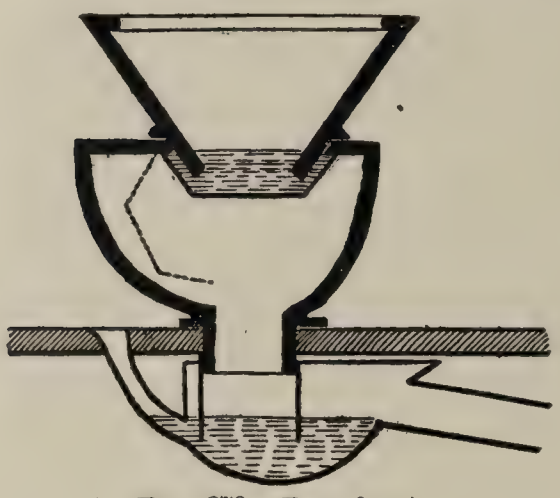


FIG. 279.—Pan-closet.

A large number of forms of water-closet apparatus have been devised, these varying more or less in detail but conforming in general to one of several main types.

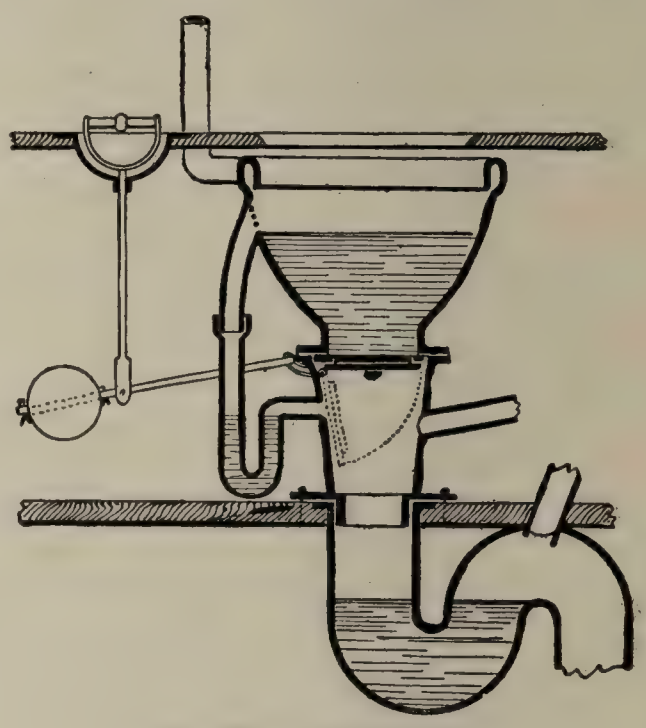


FIG. 280.—Valve-closet.

Among these, the pan-closet is one of the older models. This apparatus violates every one of the essentials agreed upon by sanitarians with respect to water-closets, and has only its cheapness to recommend it. It is mentioned because a few closets of this pattern are still to be found in some old posts, though they are no longer installed and are being gradually replaced by more modern patterns. This apparatus consists of a hemispherical pan surrounding the open bottom of a conical receptacle; the pan holding a certain amount of water and being intended to form a water-seal or trap. Frequently, from failure of water, defective apparatus or rusting of the pan, the latter is empty, so as to give free passage to noxious gases. From an insufficient supply of water delivered in an improper way, the container and pan are continually smeared with excrement. The closet pipe usually

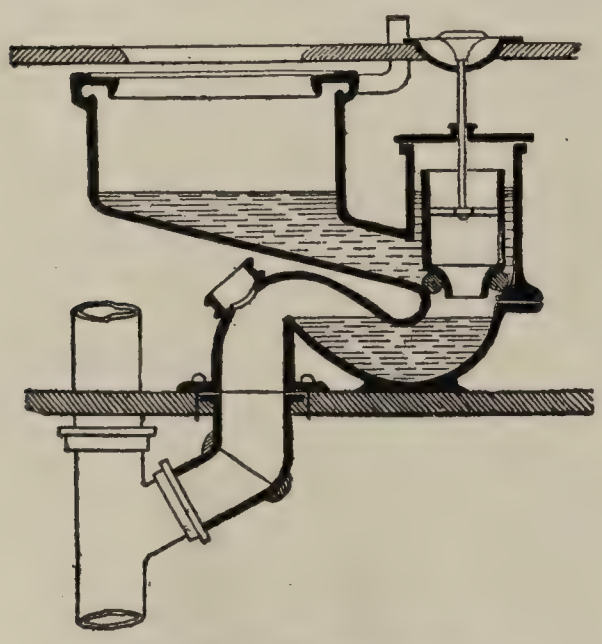


FIG. 281.—Plunger-closet.

terminates in a D trap, from which foul gases arise when the pan is drawn back. The apparatus is also very liable to get out of order.

The valve-closet is a slight improvement over the pan-closet, in that its receiver is smaller and of better shape and contains a greater volume of water. Otherwise, it is exposed to much the same objections as apply to the pan-closet; its plug, in addition, being liable to leak and thus fail to keep a supply of water in the receiving basin.

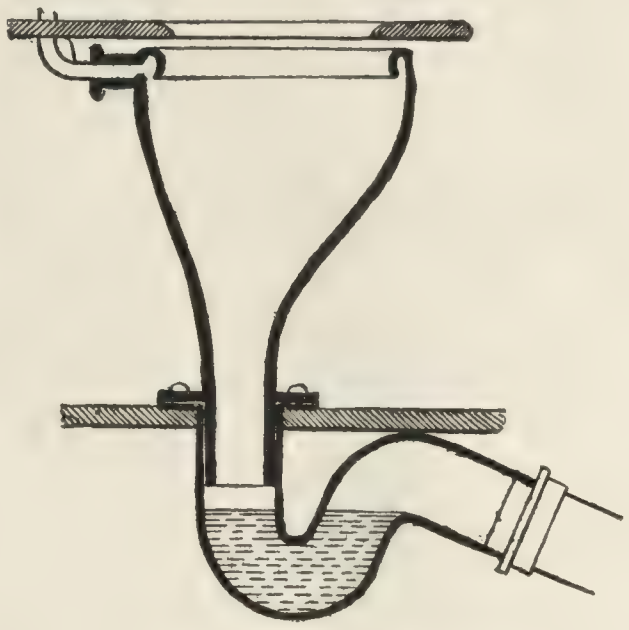


FIG. 282.—Long-hopper Closet.

The plunger-closet is constructed on much the same general principles as the valve-closet, though differing from it in form and a number of particulars. In this closet, the outlet of the bowl is at the side instead of directly below, and is closed by a heavy piston, on the raising of which the contents are discharged into an S-shaped trap leading into the soil-pipe. This closet is a much better form of apparatus than the pan or valve-closets, but has several serious defects. While the basin holds a large volume of water, flushing is very inefficient. Leakage may occur from clogging with foreign material or the retention of paper between the closet-pipe and the plug, when the latter fails to close the outlet completely. The plug also becomes very foul, cannot be cleaned and serves as a direct source of atmospheric contamination.

The long- and short-hopper closets are most simple in construction and have no mechanical parts to get out of order. This type of closet consists of a plain bottomless bowl, of different heights, set on a trap which opens into the soil-pipe. The water enters by a rim flush, generally from an overhead tank. There is no standing water in the hopper closets, so that their sides are necessarily fouled by use—hence their efficiency is largely influenced by the amount of water used for flushing and the manner of its distribution over the sides of the receiving basin. With the hopper closets of this type, the water-seal is too small to withstand even a very slight evaporation or air-pressure, and they are noisy in operation. The short hopper is the much better pattern of the two, as the level of the water-seal is nearer the seat and the trap is in view.

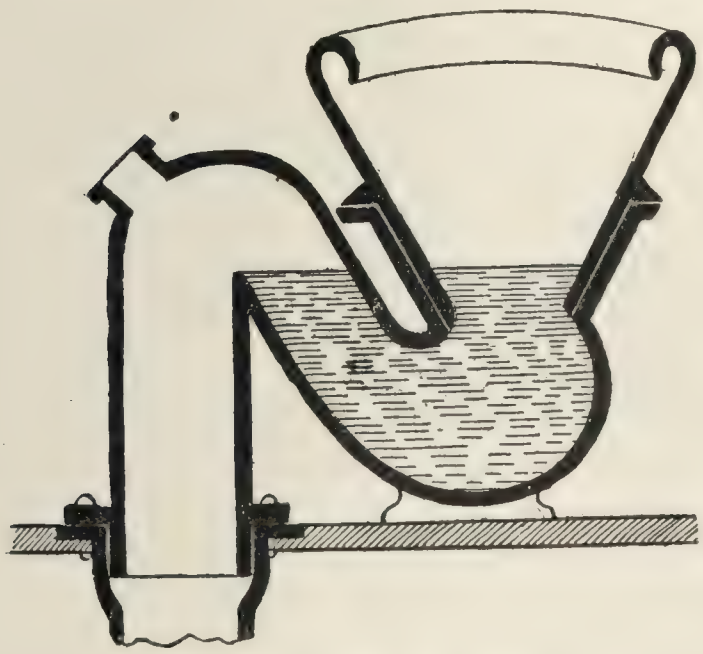


FIG. 283.—"Deluge" Closet.

Various modifications of the short-hopper or so-called "wash-down" closet have been made, of which one of the best is the "Deluge," in which a

flushing rim is so arranged that the water flows in a direction and manner which ensure the basin being constantly scoured and kept clean. In the later forms of this apparatus, the cone shape of the hopper is discarded, and the back is made vertical or recessed, so that the excrement drops into the water of the trap and not upon the side of the receiving basin. A much used and very satisfactory form of closet, of this general type, is the "Dececo."



FIG. 284.—"Deluge" Closet, with Recessed Back.

To improve the scouring effect of the modified short-hopper type of closets, as described above, a number of changes have been proposed. One of the best of these is seen in the "Century" closet, in which the service-pipe from the flush-tank has two connections with the closet, one leading into the flushing rim of the basin in the usual manner, while the other discharges into the longer arm of the siphon pipe. One stream thus scours the basin, while the other rushes down the siphon pipe, starts siphonic action and empties the basin; the latter being refilled with clean water by a simple after-flush arrangement of the tank. In the "Twycliffe" closet, besides the flushing stream, a considerable quantity of water is forcibly driven into the water-seal, so as to cause siphonage and at the same time mechanically assist in the evacuation of the contents of the closet. Some of these fixtures designed to give a quick and powerful flush of water are open to objection, under some conditions, by reason of excessive noisiness of operation.

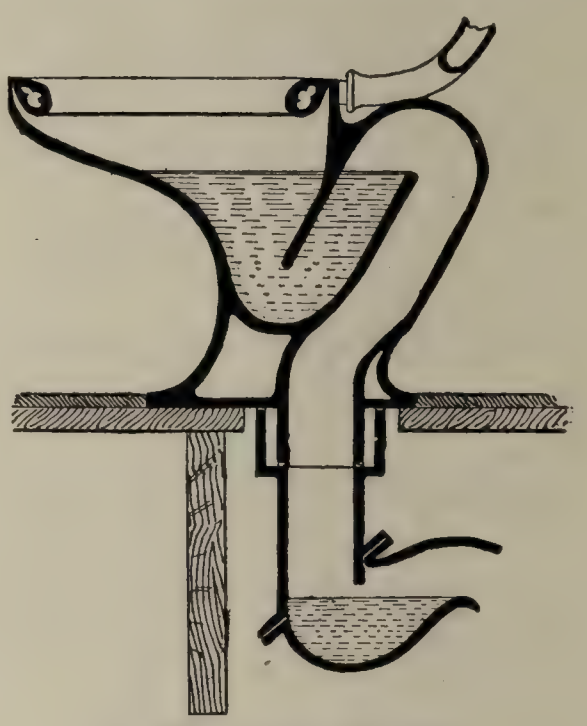


FIG. 285.—"Dececo" Closet.

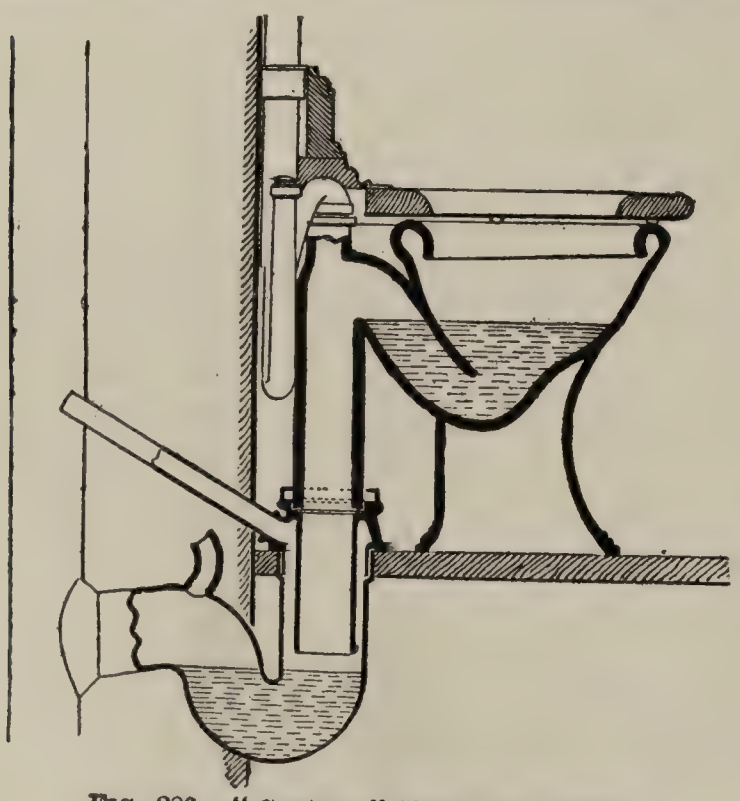


FIG. 286.—"Century" Siphon-jet Closet.

A much less satisfactory form of apparatus than the short-hopper water-closets is the so-called "wash-out" type, of which there are several modifications. In these closets, the excreta are received in a shallow basin containing water, over the rim of which the contents are carried, into a trap underneath, by a sudden and powerful flush of water.

The objections to this type of closet are many. The water in the receiving basin is not of sufficient depth to cover the solid dejecta; and if the rim is made higher to avoid this fault, the contents may not be at once carried away unless the flush be very powerful. The flushing is often attended by spattering, and the operation is noisy. The trap is hard to clean, inconvenient of access and its seal is very shallow, being readily destroyed by siphonage, evaporation or incorrect setting. The pipe-surface between the basin and water-seal is easily fouled and difficult to clean.

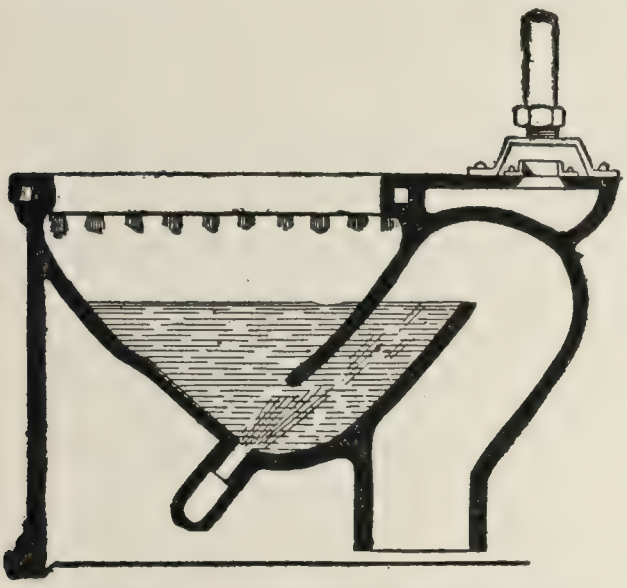


FIG. 287.—Twycliffe Siphon-jet Closet.

All these forms of closet are made in earthenware, for the better maintenance of cleanliness through the smooth interior surface thus afforded. This material has the disadvantage of being readily broken by rough handling, and, to prevent accident of this sort, other forms of apparatus, made of enamelled iron, have been devised to take the place of the individual closets where the necessities of a large number of persons must be provided for.

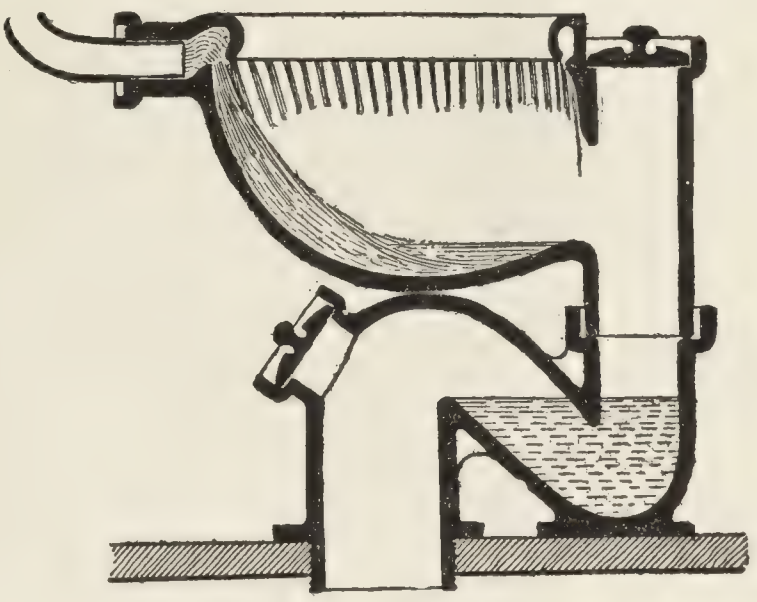


FIG. 288.—Lambeth Wash-out Closet.

Common troughs are used to a considerable extent for the reception of excreta; these connecting with the drain by a trapped soil-pipe and being provided with a supply of water. This system in its simplest form is used in some foreign armies, a trough receiving the dejecta and a certain quantity of water. A trapped soil-pipe opens from one end of the trough, being closed by a plug; the latter is pulled up several times daily by a soldier detailed for the purpose, when the contents of the trough are rapidly discharged. Sufficient water is then allowed to run into the trough to replace that which has been drawn off. An arrangement similar to the above is used at Fort McDowell, where it has been found to be unsatisfactory. Where flushing occurs at such infrequent intervals, the trough practically becomes a small cesspool; the water in the trough only partially retaining the odor of the excreta. A great improvement consists

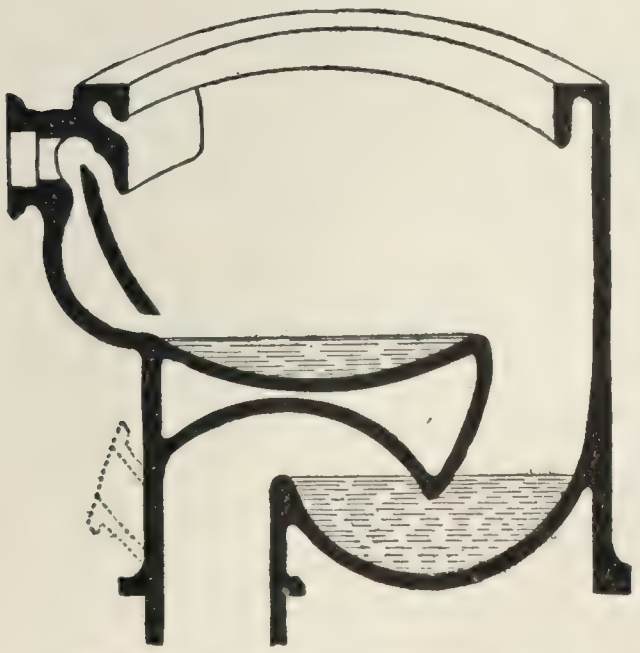


FIG. 289.—Common Wash-out Closet.

in the use of an automatic flush-tank, by which the trough is flushed out at intervals of about ten minutes and its contents are carried away. The receiving trough is usually provided with a horizontal flush-pipe running along its rear wall and having fine holes so placed as to cause this surface to be washed down during the general flushing. This horizontal pipe is located immediately under the lid, and is supposed to be out of the way of the discharges. As a matter of fact, however, it is usually spattered with diarrhœal discharges, and becomes very foul without frequent mechanical cleansing. Nearly a hundred of these latrine-troughs have been installed in our service, and nearly all have been subsequently torn out as being unsatisfactory. The trouble appears to lie in the fact that the receptacles are uniformly made too narrow by the manufacturers. If they were made six or eight inches wider, so that fæcal discharges could not be projected against the horizontal flush-pipe or the back of the latrine-trough, the arrangement would prob-

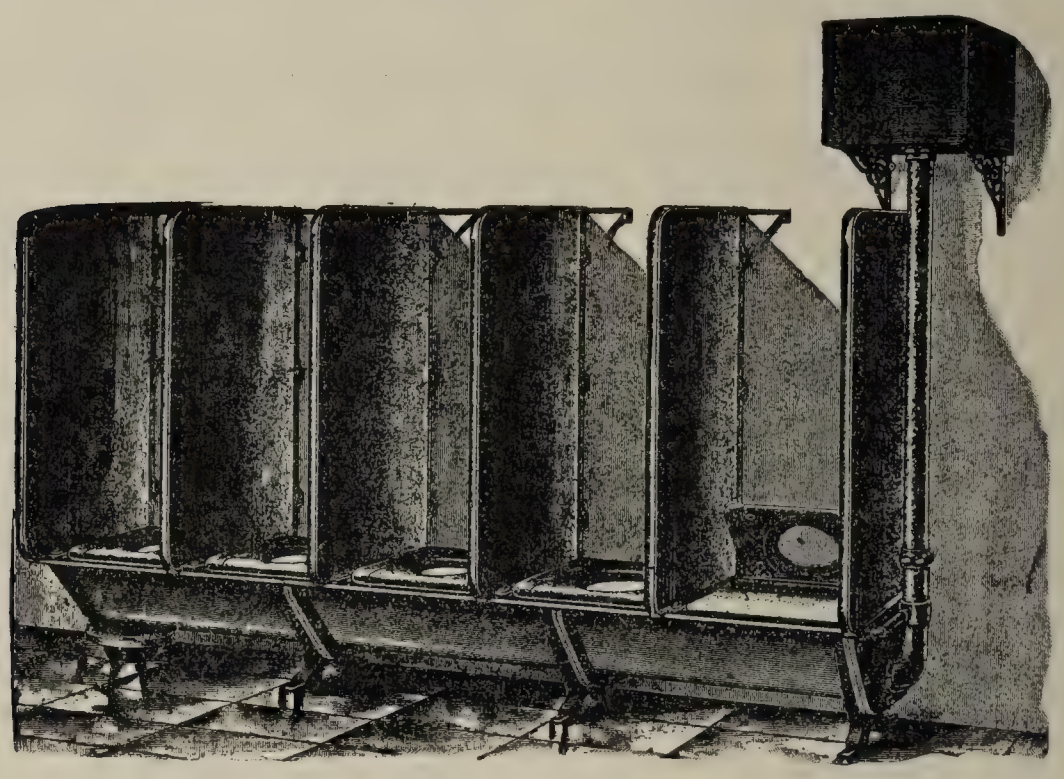


FIG. 290.—Trough Water-closet.

ably be the best which could be used in the military service. The existing faults do not depend upon the system as a whole, but upon defects of construction.

The seats in water-closets, whatever the special system employed, are best cut away in the shape shown in Fig. 166 to limit the liability of fouling by the discharges. The ordinary openings are also not infrequently made too small, and under such circumstances cleanliness of the seats cannot be maintained. To prevent absorption by the wood of the seat of organic matter resulting from excretal contamination, as well as to limit its impregnation by the odors arising from the latrine-receptacle, the rendering of the wood impermeable on both sides by the use of paraffine, according to the method already mentioned in connection with floors, is highly advisable. By the use of this process the cleansing and disinfection of the latrine-seats would be greatly facilitated. All seats in water-closets should be hinged, so that they can be turned up out of the way for cleansing or to prevent soiling if the fixture be used as a urinal. As with plumbing generally, water-closet apparatus should be freely exposed for inspection

and should never be boxed in. In the care of water-closets and the prevention of bad odors, scrupulous cleanliness rather than the use of deodorants is required—and this can be accomplished by scrubbing and thorough flushing with water. In the German army, civilians are employed to do police work of this character—the cleanly condition of the latrine being verified several times daily by non-commissioned officers. There would seem to be no reason, however, where water-carriage removes the excreta both promptly and efficiently, why the comparatively small amount of attention necessary with such latrines should not be required of the men themselves; the care of earth-closets being obviously quite a different matter from that of water-closets. The throwing of anything into water-closets, other than materials which they are intended to receive, should be prohibited on account of the obstruction thus frequently produced. Thus at Fort McPherson, in 1898, the water-closets were reported as having been choked with socks, handkerchiefs and even drawers, while sticks, bottles and similar articles are not rarely forced into the pipes. Hard glazed paper, which does not readily soften down in water, has sometimes been a cause of stoppages, and for this reason the issue of toilet paper, at present under trial—aside from the comfort and cleanliness afforded by its use—has much to commend it. This paper should be kept on hand in the latrine-stalls and distributed by special contrivances to prevent wastage; each man should not be compelled to carry his own supply, as is at present the case. There may be times when this individual supply is missing or insufficient, and the soldier is thus put to unnecessary discomfort, and his person and surroundings to undesirable pollution. An allowance of toilet paper is issued in the British army and in the German military hospitals; other services appear to make no provision in this respect.

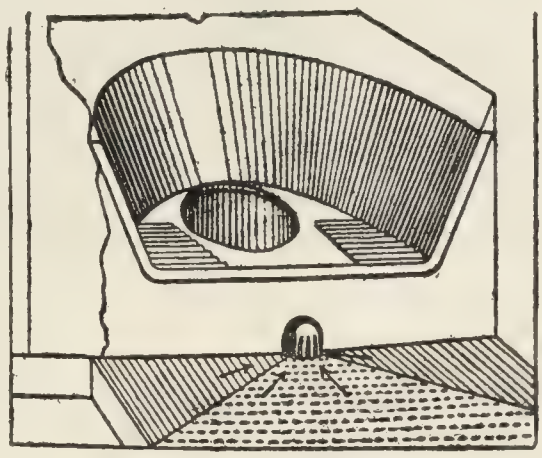


FIG. 291.—Arrangement of Water-closet Fixture for Squatting Position, as Used in the French Army. (After Laveran.)

In this connection, it may be noted that no small number of military sanitarians in foreign armies advocate the use of the squatting position during defæcation. In the French army, in barracks of recent construction, provision is made only for such a position. For this purpose, an earthenware arrangement is used by which the men are compelled to place themselves directly above the opening which is intended to receive the excreta. Places are specially arranged for the feet, and the opening is made large so as to avoid the arrest of any portion of the fæcal discharges. With this arrangement, the urine voided during defæcation is discharged forward, often being passed upon the seat or the floor in front of the arrangement for defæcation. To provide for the latter, the floor in front of the apparatus is made to slope to a central point, whence a trapped drain allows the escape of any fluids into the soil-pipe below the closet water-seal. The whole arrangement is made of impermeable material, and is kept clean by scrubbing and sluicing down with a hose. The squatting position for defæcation is advocated on physiological grounds and also as being cleaner and afford-

ing less opportunity for infection by contact. The first point may be disregarded; the possibility of infection through contact with latrine-seats must of course be admitted, but such cases are probably extremely rare in actual practice. The whole matter would seem to depend merely upon the maintenance of a proper standard of cleanliness and an efficient sanitary police.

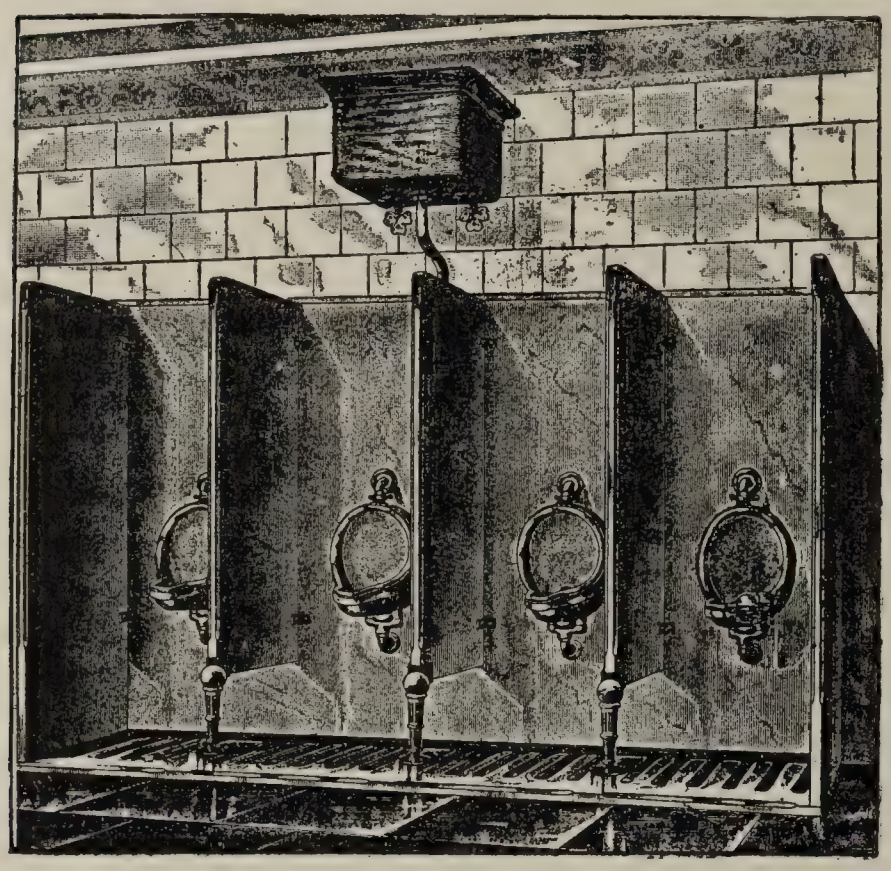


FIG. 292.—Bowl Urinal.

Where these are maintained, the sitting posture is undoubtedly more comfortable. Squatting on seats of the ordinary character, as provided in our service, inevitably results in their befoulment. It can be prevented by placing a board horizontally in its long dimension above the seat at about the height of the shoulders when in the sitting posture; the board being made to incline downward as well as backward.

Urinals. — These should be installed under the same roof as the latrines. It is desirable that they be few in number or that the surface soiled by the urine be as small as possible. They should be constructed of first-class materials and with great care and skill; the latter not being usually possessed in sufficient degree by extra-duty men.

No special type of urinal is uniform for our service, and several patterns are in use. Of these, the earthenware-bowl system is largely employed. With this arrangement, however, soiling of the floor always occurs, since the men do not stand sufficiently close to the bowls during urination. This might be avoided by placing a strip of impermeable material about two inches high and twelve to fifteen inches wide, at such a distance from the bowl that the men would necessarily have to stand upon it during urination. With such an enforced position, the contamination of the floor with urine would be largely avoided.

Since the flooring will be more or less contaminated in any case, the best urinals are probably those which have an impermeable floor and vertical receiving surface and a gutter which collects and removes the urine and flushing-water. For the impermeable receiving surface, plates of glass, painted gray on the side nearest the wall, have been much used during the last few years. This material is readily cleansed, but is liable to fracture under rough treatment. Marble is costly and too permeable for use. All things considered, the best material is probably slate; which is all but impermeable, is cheap and can be readily worked. It is not necessary to have the urinal divided into stalls, since the side walls of these are often soiled by urine and are difficult to clean. The floor of the urinal should be

constructed of slate, should be at least three feet wide and should have a slope of at least one inch toward the receiving surface, where it should fall away to form a gutter. The pipe into which the gutter discharges should of course be trapped; this pipe being guarded by a wire screen to catch any foreign articles which may find their way into the urinal.

Instead of the simple arrangement just described, a form of urinal intermediate between it and the bowl system is used in several foreign armies; the flush-water and urine passing into a trough about two feet above the floor. This trough is both unnecessary and undesirable. The near side of such a receptacle is sure to be soiled with urine, yet is not reached by the flushing-water and can be cleaned only by hand. Further, since a certain amount of urine falls on the floor and its disposal has to be provided for under any circumstances, the whole might just as well be deposited and removed in this manner, particularly since this is usually more thoroughly and satisfactorily accomplished than where only a small part of the urine requires attention.

To wash the receiving surface of the urinal, the water may run incessantly or be discharged intermittently—the latter arrangement being the better. Where the flush-water runs continually in small quantity, it is rare that all the receiving surface is washed down, since the water forms currents and leaves little dry islets. On these, urinary deposits accumulate and go on to decomposition, so that the urinal, in spite of a constant flow of water, may appear unclean and will usually have an unpleasant odor. With flush-tanks this inconvenience is avoided. All the surface is washed down by a copious discharge, and the interval between flushings is not sufficiently long to allow an accumulation of urine-salts. The flush-water is discharged from a horizontal pipe pierced with numerous small holes, the jets from these being directed against the slate by a strip of zinc so placed as to prevent splashing.

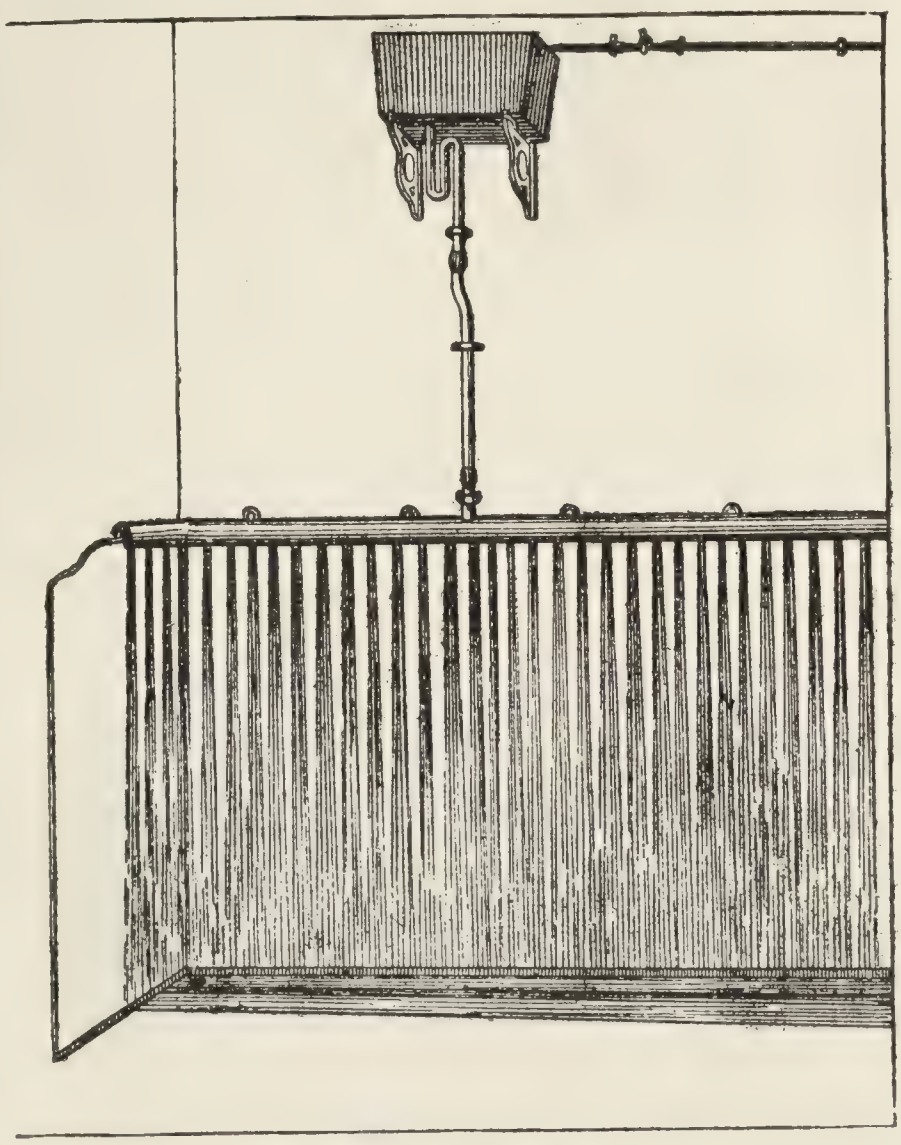


FIG. 293.—Flush-down Urinal.

Solid matters rarely give rise to the bad odors sometimes noticed in water-closets, but these are chiefly dependent upon the retention and decomposition of urine. Hence urinals should be regularly cleaned, and all deposits of urine-salts removed as soon as formed. For this purpose,

automatic flushing can never take the place of manual cleansing with hot water, soap and a stiff brush. An unpleasant odor about a urinal invariably implies an inefficient police; unfortunately this is too rarely appreciated, and such efforts as are made to diminish odors are usually limited to the opening of windows and the use of deodorizing disinfectants. The disinfection of urinals, however, except in hospitals, is rarely required.

The water supplied to urinals is sometimes rich in iron-salts, which, together with those of the urine, leave unsightly stains or incrustations on the fixtures. These can readily be removed by scrubbing with a ten per cent. solution of hydrochloric acid. This acid also promptly neutralizes any ammoniacal and mal-odorous deposits, and can be used without injuring the apparatus. Where a supply of water fails the urinal, the exposed surface should be greased to prevent the deposition of urinary sediment.

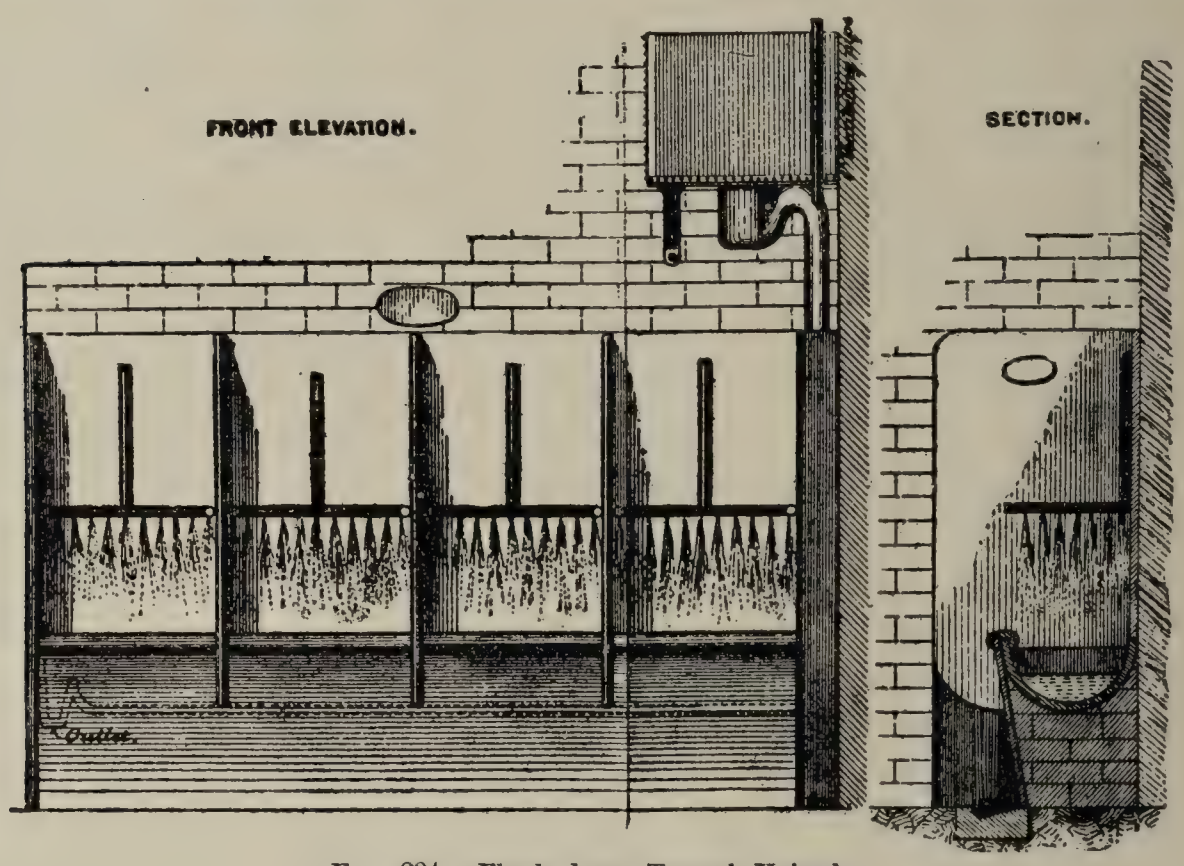


FIG. 294.—Flush-down Trough Urinal.

This is done by daily passing a mop dipped in oil—usually linseed oil—over the exposed surface. The small amount of oil carried down by the urine forms a pellicle over the fluid in the traps, and largely prevents the bad odors which might otherwise arise therefrom. This use of oil in connection with urinals is largely employed in the Austrian army. It is particularly of value for urinals where there is no water-carriage, as in posts where the dry-earth system is employed.

Flush-Tanks.—For the better scouring out of water-closet fixtures and traps, the water to be supplied for this purpose should be of considerable volume, and should be delivered with a sudden rush rather than more gradually. Where the washing out of latrine fixtures is concerned, economy in the use of water, within certain limits, is misplaced. For single water-closet bowls, a flush of two and one-half gallons gives good results in the better form of apparatus, while as much as three and one-half gallons may be required for the poorer type of closet. Beyond the latter amount, any excess may be regarded as wastage. With latrine-troughs, the allowance of water for a single flushing of course depends upon the length

and width of the receptacle and the depth of the water standing in it. With trough-closets of the ordinary type, a flushing allowance is required of about three gallons to each seat.

For the supply of a sufficient quantity of water without wastage and in the most efficient manner, the use of flush-tanks is now general. These may be automatic in their periodical action or may be mechanically started into operation when required. The tank is usually placed about six feet above the level of the water-closet seat. For single bowls, the discharge-pipe should be one and one-half inches in diameter; for trough-latrines, the size of the pipe obviously depends upon the number of seats in the fixture. A discharge-pipe of insufficient diameter impairs or destroys the efficiency of the flush. In cold weather, care must be taken to prevent freezing of the water in flush-tanks, more particularly those of non-automatic operation; but under ordinary conditions, this accident is not liable to occur with tanks which automatically discharge their contents with considerable force at frequent intervals. Besides properly modifying the character of the flush and preventing waste, flush-tanks are of sanitary value from the fact that by their use the direct supply of water to closets from the water-pipes is avoided. Flush-tanks for sewers, depending on siphonage for their operation, differ from those used in connection with water-closets only in the magnitude of their dimensions.

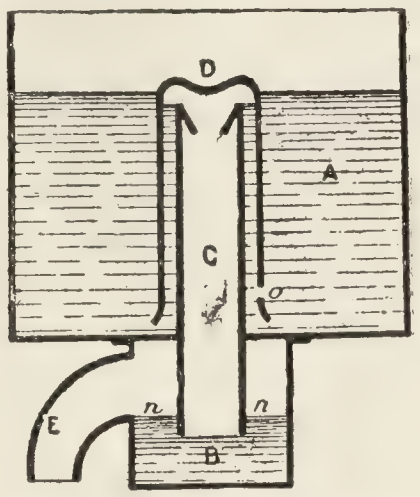


FIG. 295.—Rogers-Field Automatic Flush-tank.

For general military use, copious flushes automatically discharged at regular intervals are preferable to those depending for their operation upon attention from the men themselves. The great majority of flush-tanks operating automatically are constructed on the plan of the annular siphon devised by Rogers-Field. As shown in the accompanying illustration, this apparatus consists of two reservoirs, *A* and *B*, communicating by a vertical pipe *C*, having its upper opening narrowed by a circular flange projecting downward. The pipe *C* is covered by a metal cap *D*, which descends nearly to the bottom of the tank *A*, leaving a space between the pipe *C* and itself. This cap is pierced at *O* by a small opening. The pipe *E* discharges into the closet to be flushed. A faucet, which is not shown in the figure, allows a small jet of water to discharge constantly into the reservoir *A*. After the tank has been once flushed, water remains in the lower reservoir *B* at the height *n*, *n'*. The water which constantly passes into the reservoir *A* accumulates, and when its level has passed the orifice *O* the air in the pipe *C* is compressed more and more as the quantity of water in the reservoir increases. The compressed air forces back the water in the pipe *C* until a moment arrives when the air is forced out through the bottom of this pipe by the increasing pressure above it, water rushes in and rapid siphonage occurs. When the water has been lowered in the tank *A* to the level of the orifice *O*, a certain amount of air passes in, gradually destroys the siphonic action and prevents the water-seal in the receptacle *B* from being lost. This flush-tank must be set perfectly level to ensure a powerful action, since if it leans to one side the water passes over the lower edge of the inner tube without

strong flushing. By regulating the flow of water into automatic flush-tanks of this character, their regular discharge can be accomplished at such intervals as may be desired.

A simple modification of the above flushing-apparatus consists in the use of a curved tube, like an inverted U, which passes through the bottom of the tank, rises to near the top and then again descends so that its open mouth is shortly above the bottom. When the level of the water in the tank rises to the top of the curve, the discharge begins and continues until all the water has been siphoned off. Sometimes this single tube is replaced by a number of smaller ones, so that the tank is emptied with great rapidity and force. Automatic flush-tanks are also made in such a manner that the action of a float operates to lift a valve and allow the escape of the water after it has reached a certain height.

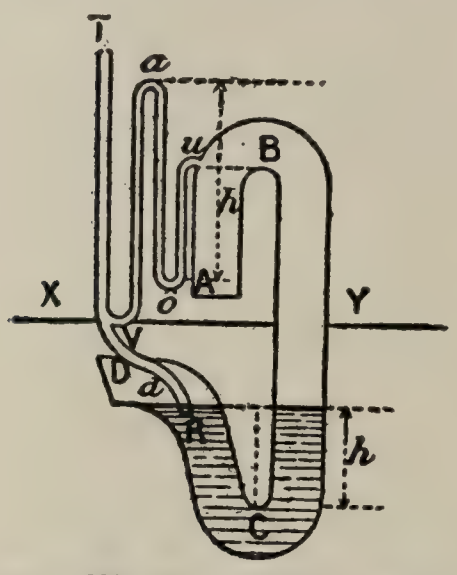


FIG. 296.—Siphon-Flush Used in the French Army, Showing Water in the Water-seal.

A siphon-flush which is much used in the French army, as shown in the accompanying figures, is a curved pipe, *A*, *B*, *C*, *D*, with its long branch, *B*, *C*, *D*, having its extremity curved in such a manner as to present a trap at *C* constantly full of water. At the point *d*, the tube *RdT* branches off; its upper end opening into the free air, while the lower end extends a distance of some centimeters into the water-seal. This tube (*dT*) is itself pierced by an orifice, *V*, at which is fastened with solder a pipe of very small caliber, twice curved on itself, and entering the other part of the siphon at the point *u*. The bottom of the curve of this pipe is pierced with a small hole at *o*, having a diameter much smaller than that of the tube. The apparatus is placed in a tank having a bottom (*xy*), some centimeters below the orifice *A* of the small arm, which also possesses a curve for holding the water, *C*, and a discharge pipe, *CD*. As water flows into the reservoir, the orifice *A* is covered. The water rises little by little above the orifice *A* in the small branch of the siphon to the same height as in the reservoir, without the pressure changing in the siphon, for the air which is displaced by the column of ascending water escapes by the orifices *o* and *u*. But when the level of the latter has attained the orifice *o*, the air of the siphon is imprisoned and compressed, and its pressure above that of the atmosphere is each instant measured by the difference in level between the water in the siphon and in the reservoir. The level of the water gradually rises in the reservoir and in the branch *oa*, until it finally attains the point *a*. The tube *uoa* thus forms a siphon. The column of water *oa* is then precipitated into the branch *aV*, if any more water passes into the tank and increases the pressure; but as the orifice *o* which connects the reservoir and the tube is less than the diameter of the latter, the water

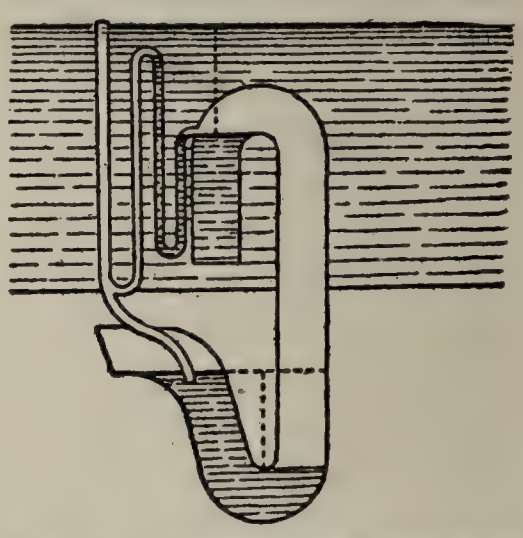


FIG. 297.—Siphon-Flush Used in the French Army. Condition immediately prior to the commencement of siphonage.

which passes through it is insufficient to feed the siphon. The column *ao* is quickly broken, and is no longer sufficient to equalize the pressure of air in the siphon. Upon this, the level of the water in the branch *AB* rises suddenly, siphonage begins in the large pipe, and the tank is emptied down to the level *A*. The tube *RT'* permits the re-entrance of air into the lower part of the conduit, for the re-establishment of atmospheric pressure after flushing. On the other side, air is drawn in through the openings *a* and *u*, thus permitting a certain volume of water to remain in the trap *C*.

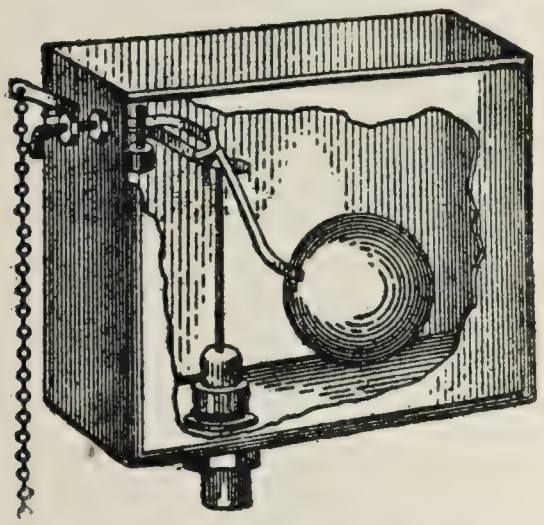


FIG. 298.—Single Valve Flush-tank.

While automatic flush-tanks are preferably used in latrines frequented by a considerable number of men, for certain uses, as for quarters and hospitals, such tanks would flush the closets more frequently than is necessary and thus waste much water. Under such circumstances, it is desirable to have flush-tanks which can be set in action only when the need for their use exists. Many varieties of these tanks are now on the market, and it is useless to multiply descriptions of apparatus of which nearly every manufacturer has his own model. With this system, each closet should have a separate tank, usually made of iron and discharged by siphonage. A float on the end of a long lever operates mechanically to shut off the water-supply, when a proper level has been reached, by closing the valve of the faucet. A short pull at the chain will start the action of the siphon, when the contents of the tank are rapidly discharged. The overflow-pipe from the tank is best made to discharge through the wall into the outer air; under no circumstances should it open into any pipe connected with the water-closets.

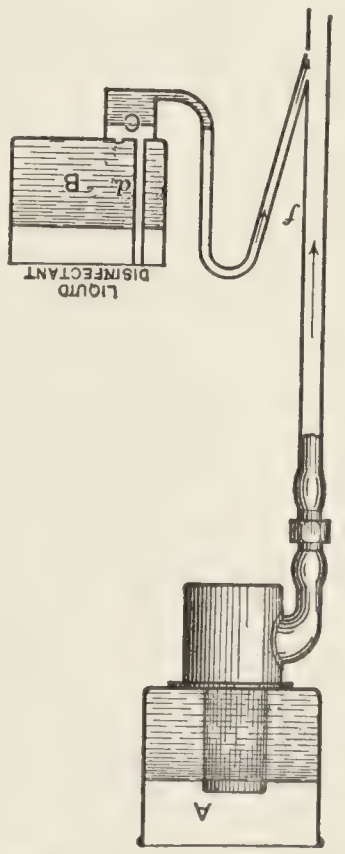


FIG. 299.—Apparatus for the Automatic Disinfection of Urinals.

While the automatic flushing of urinals with a disinfectant solution is rarely necessary, it can readily be accomplished by means of the simple arrangement shown in the accompanying illustration. In this, the tank *A* is an automatic flush-tank, while *B* is a smaller tank containing a disinfectant solution of considerable strength. Through a small aperture in the bottom of *B*, this disinfectant solution passes slowly into the small reservoir *C* and rises in the small caliber siphon-pipe to the level of the fluid in *B*. The tube *d* allows the entrance of air into the lower reservoir *C*. With each flush of the tank *A*, the water so discharged aspirates the strong disinfectant in *C* into the main discharge pipe, and dilutes the latter to proper strength before the whole is flushed through the urinal. The size of the two pipes and tanks should be so proportioned that the latter are emptied at about the same time; the strength of the disinfectant solution used should be such that when the contents of the tanks *A* and *C* are mixed, the resultant is an efficient germicidal solution.

Liquid Waste.—Waste-water from kitchens, baths and lavatories, at small unsewered posts, has not rarely been thrown out on the ground near the barracks—a method of disposal which results in constantly increasing sanitary evils. While this disposition of foul water may not at once react upon the health of the garrison, it cannot but ultimately exert an unfavorable influence in this respect. Thus from Fort Niobrara, in 1892, it was reported that soil pollution had gone on to an extent which resulted in the constant presence of strong foul odors in the rear of the barracks—comment made at department headquarters on this report being that the health statistics of this post were such as to confirm the belief of extensive soil pollution. Even in posts in which the liquid wastes are carefully removed from barracks and officers' quarters, no such precautions are commonly taken with respects to the quarters of married soldiers, and the waste water from the kitchens, laundries and baths of such habitations is generally poured on the ground. This method of disposal is highly undesirable, since ground constantly saturated with liquid filth soon becomes foul-smelling and furnishes favorable conditions for propagation of the germs of disease. There is certainly no reason why a practice which is usually strictly forbidden to the military portion of a garrison should be tolerated among its civilian followers.

Improving on the disposal of liquid waste by its deposition on the ground, slop and waste-water barrels, slop-carts and open drains have been employed—but even their use is accompanied by a gradual but nevertheless positive contamination of the soil in the vicinity of quarters. In a number of instances, liquid wastes have been removed from posts by special drains and discharged into tight or leaching cess-pools. This method of disposal is undesirable, and where a general sewerage system exists the pipes carrying the liquid wastes should of course be discharged into it; but in their arrangement such waste-water pipes should be kept separate from those of the water-closet system and should never open into soil-pipes. In England, it is required that pipes conducting waste-water shall not connect directly with any drain, but must discharge into the open air, about eighteen inches above a grating covering a good water-trap leading into the main drain. The waste-water pipes are usually three inches in diameter, with three-inch siphon water-seals.

Bath-tubs, wash-basins and laundry fixtures are usually provided with small overflow-pipes, which are either themselves trapped or are connected with the main outflow on the near side of the bend. Such pipes gradually accumulate deposits on their interior surface, which may become very offensive—and hence great care as to their cleanliness should be observed. Where a lavatory or bath is trapped by a sigmoidal bend, it should not be forgotten that odors may be able to enter from the trapping water being withdrawn through siphonage. If these odors are marked, pipes offending in this way should be traced down to the points of discharge, so as to determine if they wrongly open into soil-pipes.

Kitchen sinks have a large outflow, trapped close to the sink and provided with a strainer. As the trap is liable to become choked with sediment and accumulations of grease, there is usually a screw-cap on its convexity by which it may be cleaned. This carriage of liquefied grease by hot water is often a cause of much annoyance in connection with the

removal of liquid wastes from the kitchen, since this grease, under some circumstances, may be carried to a considerable distance along the outflow before it is deposited, and may ultimately destroy the carrying capacity of the pipe through reduction of its lumen. The disposal of greasy water is such a serious sanitary problem that French army regulations require it to be placed in tight metal receptacles for removal, while the remaining waste-water can be discharged directly into the sewers. The deposit of grease may be largely prevented or removed by a frequent flushing of the kitchen waste-pipes with a strong, hot solution of lye. This solution, made in the strength of one-half pound of lye in two quarts of boiling water, should be poured into the trap at night and allowed to remain until the next day—no other water being discharged into the sink in the meantime. Several gallons of hot lye solution of one-half the above strength should be flushed through the pipe immediately on the following morning. The ammoniacal fermentation of water-closet discharges has a considerable effect in preventing deposits of grease in the main drain.

To prevent deposits of grease in the pipes, a grease-trap or intercepting chamber is sometimes employed. This is generally made of iron or stoneware, has a tight cover and should be ventilated. The size of the chamber is proportioned to the amount of greasy water to pass through it, so as to prevent too rapid displacement of the contained water. Usually the grease-trap is divided by a central partition, dipping several inches into the water. The hot, greasy water enters at one side of this partition, while a corresponding quantity of cold water escapes through an outlet on the other side of the partition. The liquefied grease, on entering the trap, is chilled and solidified by contact with the large bulk of cold water and rises to the surface, where it is prevented from passing out by the vertical partition. Cleansing of such traps is periodically required, for unless carefully looked after they are little better than cess-pools and may become a serious nuisance. They are certainly needless except in the case of large kitchens, for with small establishments cleanliness on the part of the cook and efficient flushing with lye solution will keep the pipes clean. Under certain circumstances, the operation of grease-traps may be inefficient. Thus at St. Francis Barracks, in 1896, the choking of the drain-pipe from deposits of grease was reported despite the presence of grease-traps. The coating of grease was found to be generally distributed over the entire pipe, varying from a minimum thickness of one and one-fourth inches to one which almost completely obliterated the lumen of the pipe. This obstruction of the pipes was probably dependent upon inadequacy in the size of the grease-traps and a high temperature of the soil, by which the greasy water escaped into the drain before its grease was solidified by chilling. The water-supply of this post was also very hard and contained much sulphur, thus greatly favoring the precipitation of greasy matters.

Grease-traps should always be located out of doors, and never, as at old Fort Mackinac, placed within buildings. In very cold climates this necessity, with resulting liability to freezing, places obvious restrictions on the use of grease-traps, and under such circumstances particular care on the part of cooks is necessary with respect to the disposal of greasy wastes.

DISPOSAL OF SEWAGE AND REFUSE.

The ultimate disposal of sewage is a sanitary problem which is variously solved according to the environmental conditions obtaining in the community and the character of the material requiring disposition. Although liquid wastes alone pass into the sewers in a few posts, the term sewage may be understood for present purposes to include the solid and liquid excreta, storm-water and the waste-water from kitchens, baths and lavatories. Sewer-water thus varies greatly in its composition; being sometimes turbid, foul-smelling and highly impure, and at other times contaminated only to a relatively slight degree. Thus one ton of London sewage is said by Lawes to contain only two or three pounds of solid matter. The quantity of material eliminated by the adult male is generally fixed at about four ounces of solid excreta, by weight, and fifty ounces of liquid excreta, by measure. It is thus evident that the chief question concerning the disposal of sewage has relation less to the comparatively small amount of contained organic solids than to the great bulk of fouled water in which they are dissolved or suspended. Whether the solid excreta pass or not, however, the liquid in the sewers always contains more or less animal and vegetable matter. While an exact knowledge of the chemical constituents of sewage may be at times of importance in civil life, this question does not greatly interest the military sanitarian, who, regarding all sewage as putrescible and a possible cause of disease, is merely interested in securing its speedy removal and early destruction.

Disposal of Sewage into Cess-Pools.—This method of disposal is sometimes employed for small posts, groups of buildings or single barracks. In this method of disposal, the drain or sewer discharges into an excavation in the ground; generally walled dry with loose stones and having a floor of earth, but sometimes cemented throughout and hence water-tight. The latter form of cess-pool requires much attention and frequent removal of its contents, best accomplished by the use of the odorless excavator apparatus. As sometimes cleaned out, however,—as was the case at Fort Assinniboine, where the bath- and waste-water from the hospital and bath-house was discharged into tight cess-pools, there to accumulate, ferment and putrefy until the cess-pool was filled to the top—the contents of the cess-pool are merely pumped out on the surface of the ground in the vicinity, to soak at once into the ground or drain away, as the character of the soil or configuration of the surface may determine. There can be no doubt that the original discharge of such foul water in small quantities on the surface of the ground, where it is promptly exposed to the purifying action of sunlight and fresh air and that of the nitrifying bacteria of the soil, is far preferable to its storage until it has accumulated in large quantity and its noxious qualities have been much increased.

Where cess-pools are in use at all, the leaching variety is generally employed. Through the porous walls and floors of such receptacles the liquid constituents of the sewage drain away more or less rapidly, according to the character of the soil. In very open soils, little but solid material is retained in the cess-pool, and this is removed from time to time. Various processes for the destruction or utilization of the sludge are employed in civil communities, but none of them, save the use of such solid matters

for fertilizing purposes, have any applicability to the military service. During the operation of cleansing, care must be taken to avoid contamination of the surroundings of the cess-pool with the filth removed. In the majority of cases in which leaching cess-pools are employed, however, the soil surrounding the excavation ultimately becomes clogged with greasy particles; and as no ordinary treatment will free the ground of such obstructions, a new cess-pool usually has to be provided. In some soils and with a considerable bulk of sewage, this may become necessary every year or so, and a large extent of ground thus becomes saturated with organic filth. The economical advantage of leaching cess-pools is that the liquids escape readily and cleaning is comparatively infrequently required. This minor advantage is more than counterbalanced by the resulting pollution of the subsoil and the great danger of contaminating an underground water-supply. Cess-pools are always unsanitary and should not be allowed in a military post. If permitted, they should at least be at a considerable distance from habitations and far removed from the water-supply. Prior to their location, the trend of the ground-water should be determined. The drain leading into the cess-pool should be disconnected and trapped, and the latter should be ventilated by a tall outlet shaft—preferably painted black—and a shorter inlet. The location of cess-pools, like that of latrine vaults, should be plainly marked; in default of this simple precaution, one barrack at Fort Washakie was lately shown to have been built within three feet of an abandoned cess-pool.

When cess-pools are now put into posts, they are usually installed under the plea of temporary expediency—but unfortunately, after being once established, they are often retained for long periods or until the nuisance created by their use forces their abolishment. As illustrating this point and also showing the occasional indifference of commanding officers to fundamental sanitary rules, a system for the disposal of lavatory and kitchen waste-water, installed at Fort Assinniboine in 1896, may be mentioned. In this instance, a pipe carried the waste-water three feet from the wall of the barracks, discharging it into a drain which extended for thirty yards and opened into a leaching cess-pool. The drain in question had its top and sides constructed of boards, but possessed no floor other than that provided by a naturally porous soil. The fluid passed into this drain largely failed to reach the cess-pool, but sank into the soil close to the foundations of the building. The pipe leading into this drain was untrapped, and, from the greater inside warmth, foul ground-air was drawn into the building. This method of disposal, established despite strong protests on the part of the medical officer, is understood to be still in existence.

Discharge of Sewage into Bodies of Water.—This disposition of sewage is the one generally adopted in sewered army posts. It is ordinarily satisfactory, so far as the post itself is concerned, if the discharge be into a water-course—but under the latter conditions a nuisance may result as regards communities farther down the stream, as was recently the case at Fort Logan. Conversely, the disposal of sewage in this manner by towns may result in the creation of unsanitary conditions in adjacent posts; as at Washington Barracks, where the sewage from the city is poured into a canal which forms one boundary of the narrow reservation, and which is practically an open foul-smelling drain; or at the Presidio, where sewage from

San Francisco is discharged upon a marsh within the limits of the military reservation. Where the sewage is discharged into a water-course which subsequently becomes a source of supply, the dangers of such contamination are, of course, greatly increased. Thus the amount of sickness at Jefferson Barracks, the water-supply of which was formerly contaminated by the sewage of St. Louis, was greatly diminished when a new and pure source of water was secured. The easiest method of getting rid of sewage, however, undoubtedly consists in passing it into streams of considerable volume, where it is at once diluted and its solid constituents are oxidized, become food for fishes and plants, or settle down to the bottom. In western stations, with a comparatively unsettled country, no objections as to this method of disposal have generally been raised; but as the country develops, and particularly with small water-courses, contamination of this sort may be expected to arouse opposition from the civil communities affected.

Where sewage is discharged into the sea, the resulting dilution of the former does much to destroy its offensive qualities, in spite of the fact that oxidation of organic matter goes on much more slowly in salt than in fresh water. In many instances, however, even where small amounts of solid material require disposal, much difficulty has resulted from the action of the tides and currents. Thus at Fort Schuyler the use, as a latrine, of a building projecting over the water had to be abandoned by the command, as the excreta, instead of being removed, were deposited on the beach. Where tidal currents exist, the point of discharge for sewers should be located below the post in the direction of the falling tide. The greatest difficulty with such outfalls occurs at low water. As the flow of sewage is continuous, under such conditions the best method is to store up the sewage and discharge it by automatic apparatus on a falling tide. It was found necessary to install arrangements of this sort at Fort Monroe, where the sewage discharged at certain stages of the tide was cast upon the beach. At this station, besides securing an intermittent discharge, the sewer-pipes are extended into the currents six-hundred feet below low-water mark, and the sewage is thus efficiently carried away from the post. Sewage should never be discharged into small tidal estuaries, since it is never carried to any distance but is either deposited on the bottom or cast back on the shore. To prevent the entrance of water into tidal sewers, flap-valves are usually employed, these automatically closing with a rising tide.

Sewage-Farms and Ground-Filtration of Sewage.—Where facilities are at hand for the purpose, the putrefying animal substances in sewage can be prevented from contaminating the air, the soil or the water of streams by imitating the processes of nature and directly utilizing them as food for plant life, which in its turn may be employed as sustenance for men or animals. This method for the disposal of sewage consists in the discharge of the latter upon or into the soil in such a way that it shall be acted upon by growing vegetation. The soil acts as a filter, straining out the solids; then by the separating action of the earth-particles, a large surface of the fluid is exposed to the action of the air, with oxidation of the dissolved organic matter. This process of destruction is greatly aided by the disintegrating action of the nitrifying micro-organisms in the soil.

There are several modifications of this general method of disposal—the simplest being to screen out the more gross portions of the sewage and

distribute the remainder over the surface of the land to be employed for this purpose. The irrigation must be intermittent, so as to allow the soil to drain and receive air and not too greatly raise the level of the ground-water. The soil itself should be porous, so that fluids may readily pass through and out of it. The best kind of soil for this purpose is a friable loam; but even sandy or gravelly soils, when properly managed, will purify sewage. In the case of stiffer soils, subsoil drainage is usually required. Where this is necessary, the porous drains should have an inside diameter of about four inches, should be laid four to six feet deep and twenty to one hundred feet apart, according to the porosity of the soil. The drains should unite into a single large outlet-pipe at the lowest part of the farm, which may discharge into the nearest water-course. Where grass is grown as a crop, the solids must be screened out, or removed by settling-tanks and should be taken away from time to time. The sewage-farm should, of course, be so located that the sewage may be carried to it by gravitation. The locality selected should be gently sloping; or, better, should have a

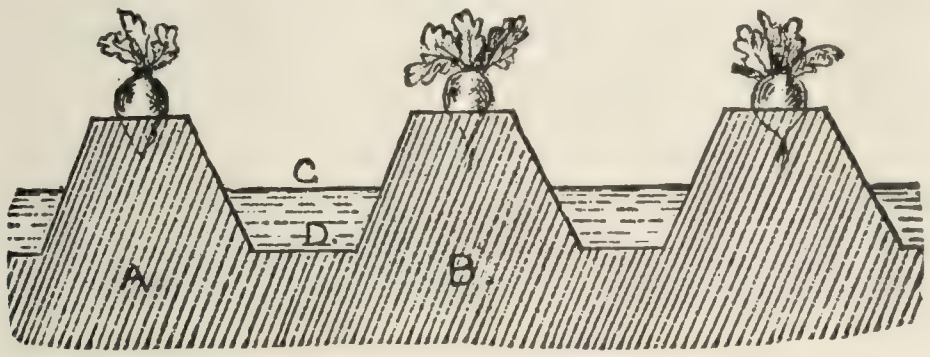


FIG. 300.—Disposition of Sewage and Vegetation in Sewage-Farms.

ridge from which the ground falls away gradually on each side, the irrigation being from the top. The sewage is allowed to trickle slowly down through ordinary trenches, provided with dams and gates for its better control. Ponding of the sewage is to be avoided, and no more should be let into a trench at one time than the soil with which it comes in contact can readily absorb. The effect of sewage-irrigation upon the growth of vegetation is remarkable, particularly upon the coarse grasses, cereals and vegetable roots. Italian rye-grass appears to flourish best on sewage farms. Where vegetables are grown, they are usually cultivated on ridges, while the sewage is discharged into the intervening furrows.

Sewage-farms, if too near habitations and not properly cared for, may become nuisances from the odors to which they give rise—but these are usually not very offensive and soon cease after the sewage once gets on the land. There appears to be no evidence that sewage-farms are productive of disease among those who have them in charge or are residents in their vicinity—as is shown by the vital statistics of Berlin and other municipalities. Salad-vegetables from such farms should not be used, nor should the ground be permitted to become swampy and water-logged. A certain amount of labor and oversight is, of course, necessary to ensure the proper operation of sewage-farms, but the expense and labor of this may be partially counterbalanced by the sale or use of the produce. The method of disposal of sewage by irrigation has been employed at Forts Bayard, Bidwell, Stanton, Logan and other existing or abandoned posts. At Fort Logan the system of disposal by this means was faulty, in that the sewage

was used for irrigation only during part of the year, while at other times it accumulated in a large pool which drained into the Platte River and created a nuisance. At some posts, the sewage used for irrigation has been composed only of liquid waste; the solid excreta being disposed of by earth-closets. Recently, at Fort Douglas, the use of the sewage for the irrigation of the post garden was proposed.

Intermittent downward filtration, as a method of disposal, differs from that of irrigation on sewage-farms in that it may be considered as the concentration of sewage at short intervals over small areas of specially chosen and prepared ground. Vegetation is not excluded, but the question of produce is made of secondary importance. The soil should be porous and thoroughly under-drained, so as practically to form a filtering-bed. The under-drained area is generally divided into four parts, each of which in turn receives sewage during a period of six hours. Intermittency of irrigation is essential to the success of the method. The sewage turned on the ground is required to be clarified; since where the crude material is applied, the soil acquires a surface coating of slimy matter which prevents the absorption of liquids and results in ponding. As with ordinary sewage-farms, purification of the sewage is brought about by filtration, oxidation and nitrification. This oxidizing quality is especially marked in rich moulds and loam. Nitrification is confined to the limits of temperature within which the nitrifying bacteria are active, being most rapid at about 37° C.; and these organisms are most abundant in the upper six inches of the soil. With sewage-farms and downward filtration, the effluent water is clean, bright, odorless and palatable to the taste. It contains relatively few micro-organisms and these are almost entirely saprophytic forms; the amount of chlorine, however, is high.

In well-drained land, the clarified sewage ma ybe applied intermittently in the proportion of one acre of ground to the sewage of two thousand people; the latter being about ten times the number whose wastes could be disposed of on ordinary sewage-farms of equal area. These estimates, however, are only approximate, since the efficiency of the methods depends upon so many variable details. Both methods appear to operate fairly successfully during winter, though, of course, they are most efficient with a temperature which permits of the growth of plant and bacterial life. The warmth of sewage usually keeps a sufficient amount of soil unfrozen, even in very cold weather, to permit of the absorption of its liquid portions.

Subsoil irrigation may sometimes be used for the disposal of sewage from small posts or groups of buildings. By this method, instead of directing the sewage over the surface of the ground by means of ditches, the liquid waste is taken into a system of loosely jointed and porous drains, located six to twelve inches below the surface of the soil, whence it escapes into the subsoil. The system requires the removal of the fat, grease and coarser solids in the sewage to prevent clogging of the pipes, besides which the latter must be dug up and cleaned at intervals of ten or twelve months. The liquid wastes are generally discharged into the pipes by means of a large automatic flush-tank, so that the penetration of the sewage to all parts of the system may be assured. This method gives fairly satisfactory results under proper conditions, the fluids being largely taken up by the roots of adjacent vegetation. It is not, however, applicable to winter use

in cold climates. One objection to this system is that the drainage enters the soil below the level of greatest bacterial activity and the liquid is chiefly dependent upon the mechanical action of the soil, and the utilization of its organic constituents by vegetation, for its purification.

Bacterial Treatment of Sewage.—This method has recently assumed importance as a simple, practical, efficient and economical means of sewage purification. It depends upon the fact that there exist in nature certain non-pathogenic micro-organisms, broadly divided into those which are aërobic and those of an anaërobic nature, whose function in life, under the conditions that their names imply, is to convert the solid portions of animal excreta and organic matter into gaseous and liquid forms by a process analogous to digestion. In the bacterial treatment of sewage, the effort is made to create conditions as favorable as possible to the development of these organisms and to secure their most efficient action.

The manner in which the disintegration and decomposition of sewage is accomplished by bacteria is given by Woodhead as follows: "The first process is the result of the activity of organisms that are capable of taking up their oxygen from the air, and, second, those the result of the activity of organisms that so break up and re-arrange the organic molecules containing oxygen that not only do the bacteria themselves take up oxygen, but they allow of its being handed on to the products to which in their process of metabolism they give rise. It is probable that here we have to do not only with nascent oxygen, but with certain products set free during the process of decomposition, which seize upon oxygen with very great avidity. This decomposition or re-arrangement is spoken of as a process of nitrification or a conversion of the nitrogenous elements into ammonia, nitrous and nitric acids, carbonic acid, and water." It would appear that the destruction of organic matter buried in the soil takes place apart from any process of putrefaction, and the action is more rapid near the surface of cultivated ground where the soil is porous and readily permeable to both air and water. Here are found, in vast numbers, the micro-organisms of the aërobic class. As the organic matter is washed down deeper into the soil it is seized upon by the anaërobic class of microbes, which, unable from their situation to obtain free oxygen, have developed the power of acquiring it from other substances which are broken down by them into simpler forms. Below a certain depth, bacteria are absent. Woodhead found this to be about twelve feet, but the number of micro-organisms present is very limited before this depth is reached, depending upon the nature of the soil, its moisture, porosity, temperature and the amount of organic matter usually present on the surface. Antiseptics and a considerable degree of heat at once arrest these chemical changes. A knowledge of these facts pertaining to the life-history of the nitrifying bacteria throws light upon a number of important sanitary points—as with reference to the disintegration of fæcal matter in earth-closets; the necessity for the intermittent in place of the continuous discharge of sewage where the latter is disposed of by irrigation; or the reason why polluted water, which escapes from a drain or cess-pool at a point below that where bacterial life can maintain an existence, will, in certain soils, infect water to a considerable distance and depth, while foul liquids placed on the surface of the soil would be cleared of impurities at the depth of a few inches.

The practical application of the above facts to the purification of sewage is made by a number of methods depending on the same general laws. By nearly all of these processes a clear, bright effluent is obtained, almost inodorous, while oxidation of all organic matter, both in suspension and solution, is secured. Provided that suitable conditions are observed

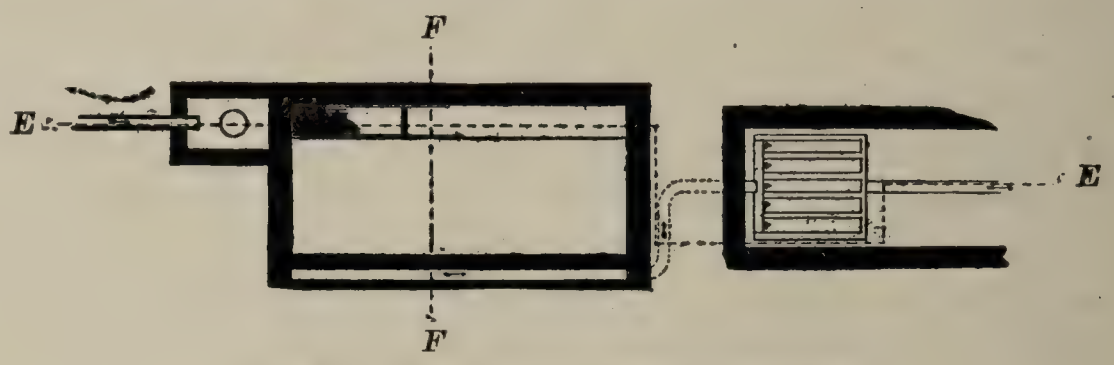


FIG. 301.—Plan of Scott-Moncrieff Apparatus.

for the establishment and cultivation of the specific micro-organisms concerned, there is almost no limit to the degree of purity capable of attainment with regard to sewage. It also appears that if the filtering apparatus be given periods of rest, its efficiency can be maintained indefinitely.

Among the various forms of apparatus, that of Scott-Moncrieff is very satisfactory. This is a filtering-tank filled up to the level of the overflows with small bits of flint, upon the surfaces of which the organisms are propagated. An iron grating supports this cultivating material and allows the sewage to escape upward from the entering channel underneath. The action in this filter is chiefly anaërobic; the effect being to bring the solid sewage into a state of solution and into a condition of instability which renders it eminently susceptible to further changes. The latter, largely in the line of a conversion of the soluble sewage into ammonia and nitrates, is brought about by the action of the aërobic bacteria in a second portion of the apparatus. This consists of a nitrifying chamber containing a number of sieves or trays, supported one above the other on a metal framework. Into the uppermost of these trays the effluent from the first tank is conducted through metal troughs, which are balanced so as to tilt when full and discharge their contents, automatically regaining their original posi-



FIG. 302.—Scott-Moncrieff Cultivating Tank. Section E.E.

tion. The liquid thus discharged into the top tray percolates into those below, occupying about seven minutes for its complete passage. Each tray is filled with small fragments of coke to a depth of six inches. An air space is provided between each of the trays so as to render the germs cultivated on them thoroughly aërobic. Since the liquefaction of sludge is naturally a much slower process than the purification of the already liquid portion of the sewage, a longer period of operation is required in the first step of the process. The longer the sewage remains in the first filter-tank

the greater the reduction in the opacity of the effluent. With respect to the secondary or nitrifying filter, it should be understood that the latter in its highest stage of biological efficiency will effect only a given percentage reduction of the pollution of its affluent. Thus if a pollution be high and the filter capable of effecting a purification of fifty per cent., its effluent will still remain a filthy liquid, and must have its contamination still further reduced by passage through another aërobic filter. These filters are sometimes suddenly and unaccountably overtaxed—a condition noted by a high elimination of ammonia—when the sewage must be passed into another nitrifying apparatus and the first filter given a rest.

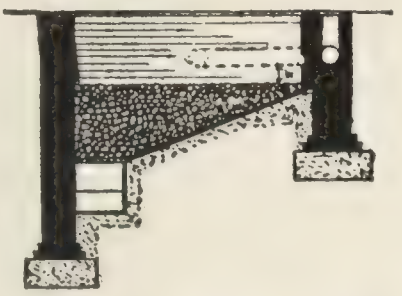


FIG. 303. — Scott-Moncrieff Cultivating Tank. Section F.F.

Mouras' "vidangeuse automatique" is an early type of the so-called septic-tank system, being an air-tight box through which sewage is passed and in which the anaërobic microbes are propagated. In Cameron's modification of this apparatus in use at Exeter, in England, in a tank having a capacity of 161,000 gallons about 90,000 gallons of sewage are dealt with daily. The sewage entering the tank is coarsely screened to arrest any foreign objects which may have gained entrance. The inlets to a small chamber, just outside the tank proper, are placed close to the bottom, and being larger than the outlets into the septic-tank, the sewage enters the chambers under a certain amount of pressure, thereby agitating any sediment and enabling it to separate from the organic matter present. From this chamber, the sewage flows over a submerged weir which divides the former from the septic-tank. The tank itself is deprived of light and air as much as possible; the sewage remains almost stationary in it for some little time, eventually escaping from an outlet at about the middle depth. Under such conditions, the anaërobic microbes multiply with such great rapidity as soon to dominate the situation, and were it not for the entrance of fresh material would soon be destroyed by their own products. Through a window in the center of the tank may be seen a layer of floating scum containing the lighter solids, and at the bottom a thin layer of heavier sediment. The greater part of the organic matter of the floating substance being dissolved, the residue falls to the bottom, but here it is apparently seized upon by bacteria and a bubble of gas is formed which buoys it again to the top; here the gas escapes and the particle of solid sewage again falls and the process is repeated while any organic matter remains. The contents of the tank are in constant movement from the bubbles of gas and the particles ascending and descending. The residue resulting from this treatment consists of inorganic ash upon which the microbes cannot feed. This residue is small; two million gallons of sewage passing through a tank twenty-four feet by nine feet leaving only four inches of sediment, while a liquid effluent of a brownish-yellow tint was the result. Upon leaving the septic-tank, the liquid sewage has a slight odor; but this is soon lost by aëration in overflowing the sides of a V-shaped trough through which it passes on the way to the nitrifying filters. These are five in number, two being in alternate use and one at rest; it having been found that each filter should have a rest one week in four. From these filters, which contain coke, breeze and clinkers to a depth of five feet, it is possible to obtain from an origin-

ally foul sewage a perfectly clear filtrate containing a fifth of organic nitrogen per 100,000 parts, which is less than the amount suggested as admissible for Great Britain by the Rivers Pollution Committee.

From what has been said, it is evident that this simple and inexpensive method of sewage disposal would be specially applicable to military posts, under conditions where the discharge of unpurified sewage into streams, or its use on sewage-farms, would not be practicable.

Precipitation.—The precipitation of sewage in tanks, by natural sedimentation and by precipitation with various chemical substances, is carried out in some large cities. The liquid thus clarified is allowed to flow over land or filter through it, though sometimes it is passed directly into streams. The sludge is removed from the settling-tanks at frequent intervals. Lime, lime and aluminum sulphate, lime and protosulphate of iron, aluminum sulphate with blood, clay and carbon are all substances or combinations of substances which have been employed. These form bulky precipitates which entangle and carry down all suspended matter. The effluent water after precipitation is merely clarified sewage, and it would undoubtedly be unsafe to use water from a stream which had received such partially purified sewage higher up in its course. In view of the cost of artificial precipitation of sewage and the far better methods for its purification, chemical precipitation possesses no advantages for the military service.

Disposal of Garbage and Refuse.

The maintenance of posts in a sanitary condition, as with all other collections of habitations, depends upon the proper disposal of filth of all sorts—among which, next to the excreta, that of garbage is of the greatest sanitary importance. The proper collection and removal of this material has already been discussed in connection with the sanitation of standing camps, and the subject requires no further consideration in this connection save in respect to the manner of ultimate disposal. In the German army, all garbage is carefully collected in large covered barrels and sold, the purchaser removing the same twice daily. This arrangement, however, is frequently impracticable in our army, and is nearly always undesirable. Frequently the garbage has been thrown on a dumping-ground in the vicinity of the post; ground near the inhabited area usually being selected from convenience, and the accumulation of years ultimately becoming so extensive as to be a reproach and a nuisance. Ashes and cinders may be used on roads or for filling, and if not required for this purpose their deposit on a general dump is not injurious. Stable manure may sometimes be used for the fertilization of post gardens, while the excreta are generally disposed of by water-carriage. Nevertheless there is always much solid waste at every post which is best destroyed by fire, and for the accomplishment of this a crematory of suitable size should always be available. Particularly where the military reservation is small and is surrounded by civil communities it is imperative that the waste should be destroyed by such apparatus. Of late years, efficient crematories have been constructed at a number of posts, among them being Forts Leavenworth, Sheridan, McPherson and Sam Houston. One built at Columbus Barracks proved to be inefficient and fell into disuse. A crematory constructed at Fort Co-

lumbus in 1885, and rebuilt six years later, consists of a fire-brick chamber divided into three spaces by iron gratings which support the garbage and refuse. A tall chimney gives a powerful draft and combustion is excellent. There is no offensive odor and the smoke is scarcely perceptible, in spite of the fact that no special arrangements were provided for consuming the products of combustion. At present, a number of types of

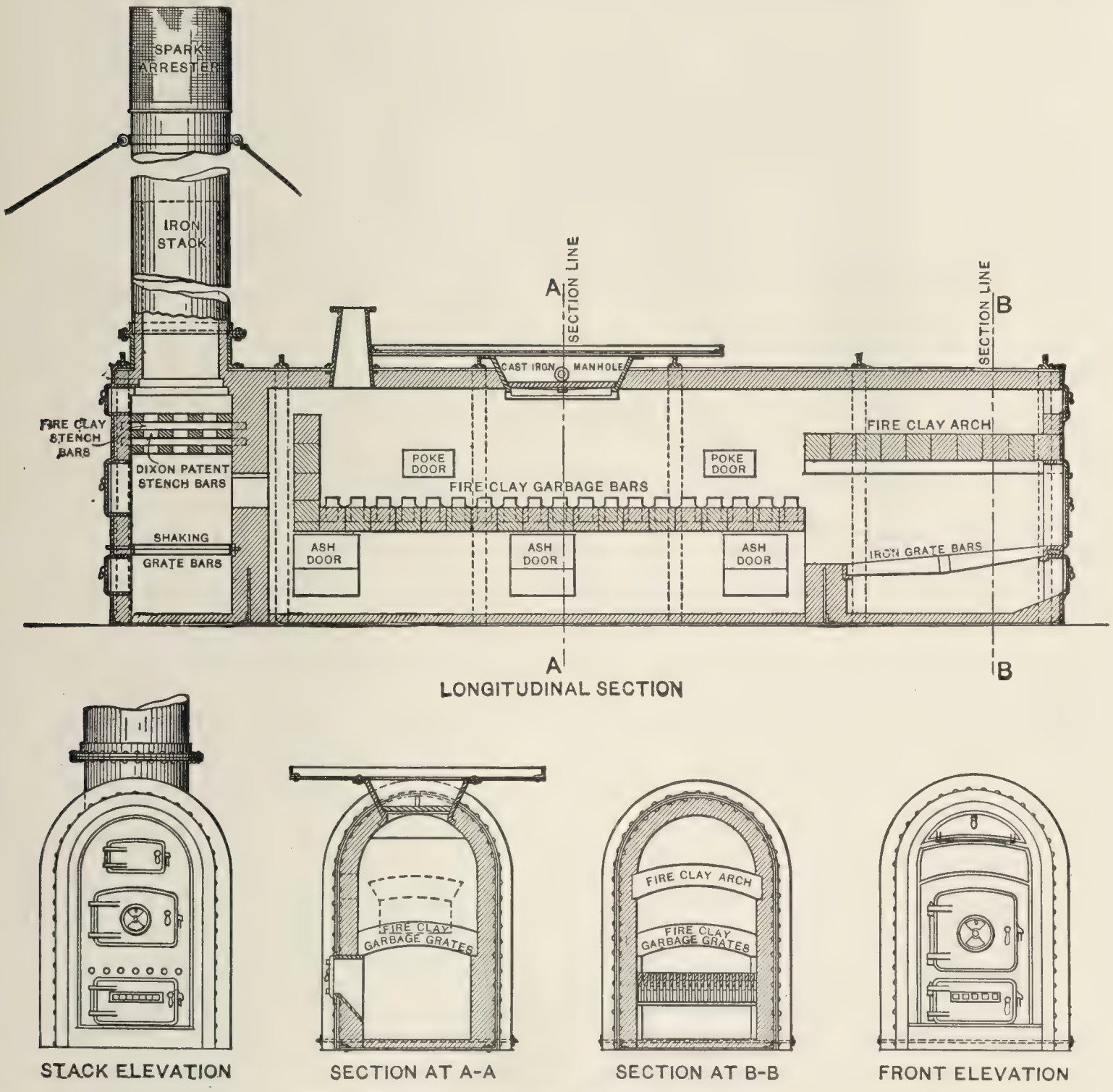


FIG. 304.—Recent Model of Crematory for Post Use.

crematory are in use in our service. The most generally satisfactory model is the one shown in the accompanying illustration; crematories after this plan having been recently constructed at a number of posts in this country and in the tropics. In this apparatus, the heat from the burning garbage and refuse, after the combustion of this is once started, is of much value in drying and destroying subsequent charges of waste material. The destruction of excreta by fire is accomplished only at stations where the Smith crematory, described in connection with the sanitation of camps, is in use.

CHAPTER XIII.

THE PERSONAL CLEANLINESS OF THE SOLDIER.

THE maintenance of personal cleanliness is even more essential in the military service than under the ordinary conditions of civil life; to some degree on account of the arduous duties often required of the soldier, with their concomitants of dirt and sweat, but particularly because of the military necessity of living in common. The importance of proper bodily cleanliness, however, was long unrecognized and in former times the barrack-yard pump, with bucket or hand-basin, afforded the only facilities available for the performance of his ablutions by the soldier. Under such conditions it is evident that no very extensive toilet could be accomplished; a daily washing of the hands and face, with an occasional foot-bath, being about all that could be attempted in inclement or wintry weather. Until a comparatively recent period, cold baths in sea or river afforded the only facilities for the attainment of general bodily cleanliness among troops of all countries; a condition of affairs which obviously left much to be desired with respect to the physical purity of the soldier. Baudens, in referring to the former lack of personal cleanliness among the French troops, says of the forces at the Crimea: "On a review day our soldiers presented, by their new and well-brushed uniforms, an irreproachable military aspect; but these fine battalions left, as they passed, the well-known stench of the barracks." Not until about the beginning of the present generation was any provision officially made in the military service for the cleansing of the person; the soldier himself being duly educated in the belief that diligence in the brushing of the uniform and polishing of the equipment amply replaced such a supposedly unimportant deficiency. Bathing of the entire body, except in summer, was thus rarely performed; if actually carried out, it was accompanied by so many discomforts and difficulties as to be not soon repeated.

In this respect, the conditions existing in the United States service during the past will scarcely bear close scrutiny. The general installation of bathing facilities among our military posts dates from a period barely fifteen years gone by, while even within the last five or six years the arrangements for the attainment of bodily cleanliness by the soldier, at a number of posts, have been of a most insufficient and primitive character. For such a condition of affairs the medical staff is in nowise responsible; sanitary reports for many years teeming with references to the deplorable lack of bathing facilities existing in various army stations. The fault is entirely that of officers of high rank in the line and of officials of the supply department; indifference and lack of initiative being, in their case, euphoniously designated as conservatism. In this respect, however, the United States army has not alone suffered. So late as 1856, the Royal Commission investi-

gating the conditions existing in the British army found that, up to that time, no arrangements whatever for bathing were provided in the military establishment; the soldiers being forced habitually to employ for the washing of their feet and persons such tubs as were used in barracks for the reception of the urine voided during the night. In the French cavalry service a system was until recently in operation—if indeed it is not even now in use in Algeria—by which the heat produced in the fermentation of stable manure was utilized for the warming of water employed for bathing purposes. Barrels containing the water were buried in the decomposing compost heaps; the water, under ordinary conditions, attaining a temperature of 28°–30° C. in twenty-four hours; 40°–45° C. in forty-eight hours and 66°–70° C. after six days. In the same service, also, the bath-houses have often been located in close proximity to the hospitals to permit of warm water being drawn from that source—the fact that the hospitals may, and frequently do, contain cases of a contagious nature apparently receiving no consideration where an economy of fuel is concerned. Of late, however, a marked change for the better, in this respect, has occurred in the military services of nearly all nations; the importance of bodily cleanliness, as affecting the health and efficiency of the soldier, has been generally recognized and adequate provision made for its maintenance.

It is evidently impossible to determine exactly the influence which the provision of better facilities for the maintenance of cleanliness among troops has had upon military morbidity and mortality, since improvement in this respect has been accompanied by changes for the better in other environmental conditions which also powerfully affect the well-being and efficiency of the soldier. In 1886, when substantially improved arrangements for the cleansing of the person of the soldier were being introduced into a number of military posts, the constant non-effective on account of disease, in the United States army, was 41 per 1,000 strength. For the following decade (1886–1895) the non-effective was 31.62, while in 1897 it was 26.73—a decrease of 34.81 per cent. It is only fair to presume that this reduction depended, at least in part, upon the greater attention given to the personal hygiene of the soldier. During the war with Spain, of the several volunteer regiments encamped at Augusta, Ga., a marked difference was noted in their respective sick-rates. The reason for this difference was reported by the medical officer attached to the regiment presenting the least sickness, and possessing at the time the only bathing facilities, as follows: "While we are not prepared to say that the lower sick-rate is due entirely to the use of this bath-house, yet we believe that the perfect system of bathing in this regiment plays no small part in its decreased sick-rate." In the French service, it was noticed by Haro that the general installation of adequate bathing facilities resulted in a considerable diminution of affections of the skin among the troops.

Cavalrymen, on account of the nature of their duties, must usually pay closer attention to the cleanliness of the person than would be necessary for foot troops—but every soldier, when in garrison, should be required to wash the face, head, neck and feet once daily, cleanse the hands prior to each meal and bathe the entire body at least as often as once in five days. In addition, a frequent toilet of the genitalia is of advantage; since it renders the soldier attentive to the first manifestations of venereal dis-

ease, prevents possible multiplication of the pediculus pubis, and enables young soldiers to escape that scrotal pruritus by which they are so often inconvenienced, particularly in hot weather.

The cleanliness of the person and garments of the soldier should be a constant object of solicitude on the part of his superiors, while the taking of general baths should be made a matter of official record. In the armies of Great Britain, France, Germany and other countries, the soldiers are regularly inspected by medical officers, at short intervals, to ensure due cleanliness of their persons and clothing as well as for the early recognition of cases of existing contagious or venereal disease. It is much to be regretted that a similar custom has not been officially instituted in our own service and that the feelings of the individual are treated as of more importance than the general welfare. It would be of advantage if at least once a week a careful inspection of the persons and apparel of the men could be made; the neck, breast, arms, feet and legs being bared for the purpose.

Lavatories.—These should be readily accessible from squad-rooms, although not in direct connection with them, to enable men while partially clad to reach them without danger of chilling. Lavatories wholly detached from barracks, while preferable in warm countries, are undesirable in cold climates; since frequent sudden transitions from heat and cold, without proper measures for protection on the part of those exposed, are often provocative of sickness. The best arrangement under such conditions consists in connecting a small outbuilding, devoted to toilet purposes, with the company barrack—the connection being made by a covered passage provided with lateral doors and windows to permit of transverse ventilation by perflation. The floor of the lavatory should be well drained and of a material impervious to moisture, while all parts of the apparatus or plumbing should be readily accessible for purposes of cleanliness. The room itself should be large, sunny, well ventilated and sufficiently warmed, since to perform his ablutions properly the soldier must uncover his neck, arms and the upper portion of his chest; an action he will not take unless the room be free from chilling air-currents and is maintained at a comfort-

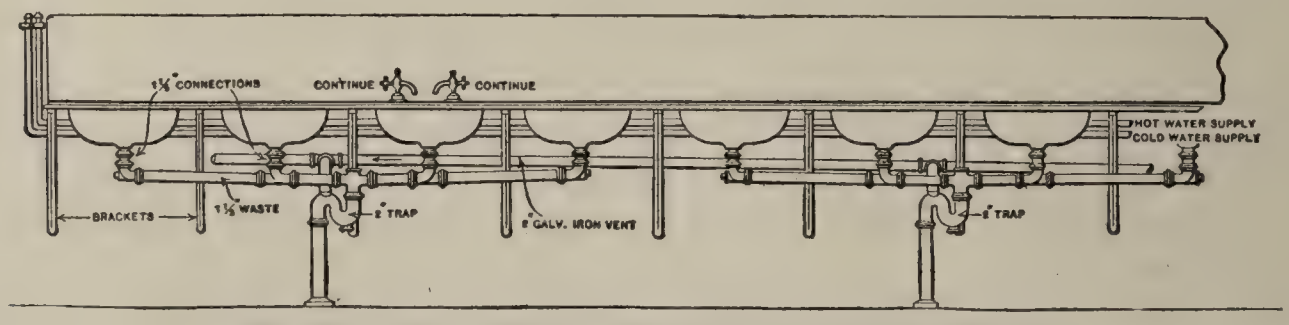


FIG. 305.—Plan in Section of Sunken Bowl Lavatory Fixture.

able temperature. Lavatories should be so arranged, connected and conducted as to render the maintenance of personal cleanliness by the soldier a valued privilege rather than an irksome task.

In the United States military service there are nearly as many varieties in lavatory equipment as there are garrisoned posts. Of late, however, two general plans have been selected for future use; one consisting of a number of sunken bowls supported in a solid metallic frame, while the other is merely a broad, shallow trough furnished with removable

granite-ware hand basins. The trough plan appears to be preferable; since, according to Bertrand, wash-bowls, when used in common, may serve as agents for the propagation for contagious disease. For the better maintenance of their cleanliness, also, lavatory basins should be movable rather than fixed. In the French service neither basins nor washstands are provided, but the soldier is expected to perform the daily ablution of face, neck and hands with a small jet of water, turned on as required. The faucets are placed at intervals of thirty centimeters along the wall and are so

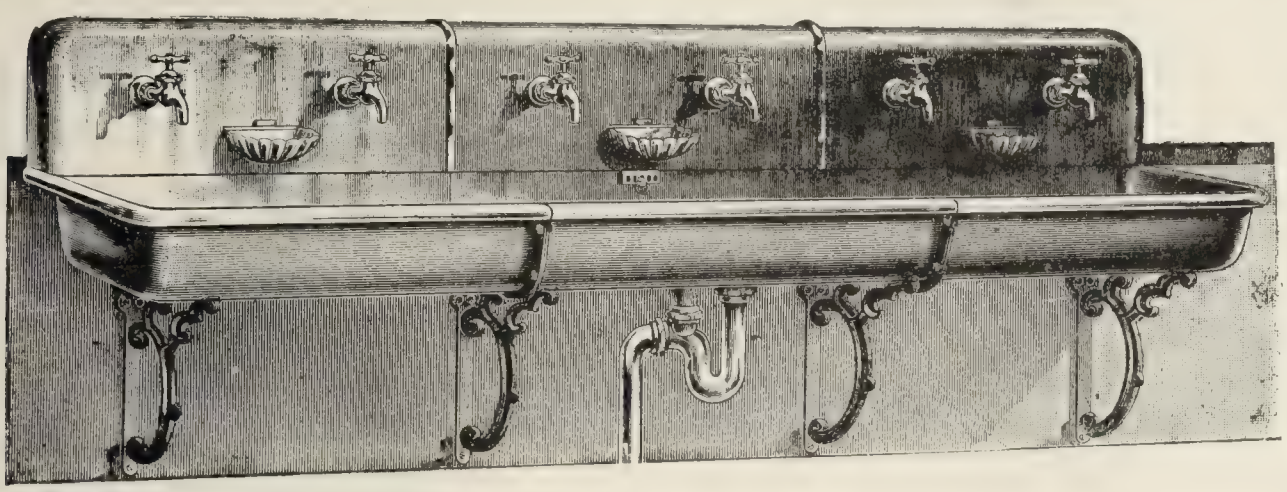


FIG. 306.—Lavatory Trough, as Used in the United States Army.

constructed as to yield a sufficient flow without wastage. They discharge into an open trough raised to a height of forty-five centimeters above the floor, the trough being intended for use in washing the feet. The plan seems to be not without considerable advantage, as affording ready facilities for the cleansing of the feet without the necessity of a general bath.

In our army, no proportion is officially required to be maintained between the number of men to be accommodated in barracks and the number of lavatory basins to be supplied for their use; but company lavatories, as at present being constructed, contain ten or twelve hand-basins. This number is ample for the needs of a peace strength of sixty men to the company, but is evidently not sufficient for the full war strength of double that number. A minimum proportion of one basin to each eight men should be required. In the British military service the official allowance is twelve hand-basins to each one hundred men, but in addition four foot-baths are also provided.

In the British and some other foreign armies, warm water is not supplied to lavatories even during cold weather. The use of such tempered water, however, is always advisable, both on account of the increased comfort afforded troops and the more ready cleanliness obtained by its use. Each soldier should be required constantly to possess, for his individual use, a piece of soap of good quality and one or more clean towels. The use of toilet articles in common should be strictly forbidden. Towels in particular, if used in this manner, may readily transmit many contagious affections, notably purulent conjunctivitis—a disease formerly so prevalent in armies as to be known as "military ophthalmia."

Baths and Bathing.—Bathing of the person, when properly performed, is cleansing, exhilarating and enjoyable. The application of water to the surface of the body not only removes epithelial débris, dirt, grease and perspiration, but it also stimulates the cutaneous functions and

acts as a tonic to the system as a whole. Since the pores of the skin are only partially self-cleansing, in the absence of bathing a certain amount of cutaneous irritation must naturally result and the elimination of an increased amount of effete material is thrown upon the kidneys. The bath should preferably be taken in the morning and bathing at night is generally to be avoided. A general bath should not be taken within two hours immediately following a meal, or while the individual is perspiring or is exhausted by fatigue. There is less danger in the application of cold water to the surface when perspiring, however, than there is in exposing the person, in a partially nude condition, to chilling by evaporation. In taking cold baths of any kind, the muscles should be kept in constant action and the head should first be wet; the latter to prevent the too great increase of encephalic blood-pressure which may accompany a gradual immersion from the lower extremities upward. Cold baths taken immediately after exercise but after the cessation of perspiration, if not too prolonged and if followed by vigorous friction of the surface, largely relieve fatigue and give a sense of exhilaration. Chilliness, with numbness of the extremities, is a warning to discontinue a bath; the body, after bathing, should be thoroughly dried by brisk rubbing with a coarse towel. This stimulates the cutaneous circulation and prevents chilling through evaporation of the surface moisture; it also removes the greater liability to chafing and eczematous eruption where the skin is subjected to friction by clothing. Soft water is preferable for bathing purposes, since it prevents or reduces cutaneous irritation as well as being more cleansing in its action and economical of soap.

In France, the rain-bath system has been officially adopted in the military service, each soldier being required to bathe the entire person at least once every seven days. The same system is employed in the German army; the douche playing for two periods of one and one-half minutes each and using 15–20 liters of water for each individual—weekly baths being required. The shower-bath system is also in use to some extent in the armies of Austria and Belgium, although in the former country there are no official requirements as to the frequency of bathing. Steam vapor baths are used in the Russian army and by the troops of Roumania. In Russia, the military barracks are not usually provided with bathing facilities and the men are sent to the public bathing establishments in the vicinity. In the camp at Krasnoë-Selo each soldier is required to take a vapor bath once in eight days. Tub baths are still used in Holland; the soldier of the Dutch service being required to bathe the entire person once weekly, half an hour being allowed for the procedure. In the Japanese army each soldier is required to bathe daily in summer and thrice weekly in winter, tubs being used for the purpose. Tub-bathing is also largely employed as yet by the British troops on the home stations. At various English barracks, notably those at Chelsea, the bath-room is located in close proximity to the kitchen. The tubs are supplied with cold water only, and the individual bathers are required to procure from the kitchen tanks such hot water as may be necessary. Such an arrangement is clearly unsatisfactory. In the army of the United States, the tub-bath system was alone employed prior to 1898, when shower baths were installed in several military posts; regulations simply providing that the soldier shall "bathe frequently."

In the military service, swimming, already discussed in connection with the physical training of troops, is indulged in at the present time for purposes of instruction, exercise and pastime rather than for bodily cleanliness, except during field service. As favoring physical purity as well as for other reasons, it should, however, be encouraged under all suitable circumstances. Troops should be prohibited from bathing in bodies of water which have been contaminated with sewage, since the cause of neither health nor cleanliness is advanced under such conditions. If the matter be left to their own discretion, soldiers will not hesitate to bathe in almost any water, no matter how great its foulness. Surf-bathing, besides its cleansing properties, has a particularly tonic effect, together with an additional cutaneous stimulation due to the sea salt.

The use of vapor baths in the United States military establishment, as is customary in the Russian army, is wholly inadvisable; on account of their increased cost and the greater time necessary for their accomplishment, and also because the method is neither popular nor well known in this country.

Tub baths, still in use in several armies, are mentioned only to be condemned. They should have no place in the military service. They are expensive, inconvenient and unsanitary, and are not practicable for use for the bathing of a large number of men in a short period of time. Tub baths, while possessed of many grave disadvantages, have no desirable qualities which are not shared in even greater degree by rain baths.

The rain or shower bath has every important advantage when compared with the tub bath or immersion system. The first cost of the apparatus is considerably less, while the subsequent outlay for operation and repairs is also reduced. The fixtures are of the simplest character and there are no parts liable to injury even with ignorant or rough usage. Repairs, if needed, can never be of a costly nature. The rain bath is cleanly and economical in management where a large number are being bathed, since it is always in readiness for immediate use and requires little attendance—while the bather is assured of an ample supply of constantly clean water. No time is lost in the filling or emptying of tubs, and the necessary cleansing of the latter, after use, is entirely avoided. The rain bath also requires less time for its application while even more efficient in cleansing the bather, and hence more baths can be administered in the same space of time. Exposure to its action for five minutes is ample for all purposes of cleanliness—a duration of only three minutes being considered as sufficient in the French and German services. The apparatus occupies much less floor space than a proportionate number of tubs, and thus more bathers can be accommodated at the same time in a given area. In the rain bath, also, the body of the bather does not remain in contact with soiled water, the waste at once flowing down from the person and escaping through the outlet, while in the tub bath the individual is constantly immersed in a solution of his own eliminatory products. Thus Edel has calculated that the average number of microbes given off by the person of the adult human being during a bath, based on the hypothesis that the individual bathes once daily, amounts to 3,860,000,000. Among the micro-organisms so given off, the bacillus coli communis was invariably found by him to be present. A bath by immersion, particularly if the water be very

warm, has often a debilitating effect and fails to refresh the bather—whereas the descending fine stream of the rain bath acts both as a general tonic and a powerful stimulus to the circulation. According to Edgecombe, the effect of immersion in cold water is to raise the arterial and lower the venous pressure through peripheral constriction.

COLD BATH—TWO MINUTES AT 13° C.

	Pulse rate.	ARTERIAL PRESSURE (MM. HG.).		Venous pressure (MM. Hg.)
		Maximum.	Minimum.	
Before	70	190	130	25
After	72	210	150	10

If to the effect of cold that of percussion is added, in the form of a strong rain douche applied simultaneously to the whole surface of the body, the arterial pressure becomes raised to a greater extent than with cold alone, while cardiac action is increased. In a strong shower bath begun at 37° C. and rapidly cooled down to 16° C., extending over a period of two minutes, the following results were obtained:

	Pulse rate.	ARTERIAL PRESSURE (MM. HG.).		Venous pressure (MM. Hg.)
		Maximum.	Minimum.	
Before	64	115	85	15
After	72	150	115	10

The effect of warm baths, on the other hand, is to reduce the arterial pressure to an extent roughly proportionate to the increase of temperature; but if the warm water be applied as a douche, the elevation due to the percussion greatly overbalances the lowering effect of the temperature. It was found by Berblinger in a series of experiments carried out upon twenty-two medical officers of the Russian army that the average muscular strength of the individuals observed rose from $108\frac{37}{42}$ kilograms before a cold shower bath to $117\frac{4}{42}$ kilograms fifteen minutes after the bath; and was still $115\frac{10}{42}$ kilograms at the end of half an hour.

An important advantage of the rain bath for the military service is that it requires much less water to achieve the same results; fifteen per cent. of the water used in an ordinary immersion bath sufficing for an ample shower bath. The danger of communicating skin or other diseases by means of infected fixtures is, with the rain-bath system, of course entirely avoided.

In using the shower bath, warm or tepid water is more efficacious from the standpoint of cleanliness. The nozzle should be turned so that the spray is projected obliquely against the body; thus avoiding the disagreeable sensation of suffocation which accompanies the impact of vertical spray upon the head. The bather should stand in a shallow tub or depression in the floor of the cell, so that the soapy water, when washed from the person, may collect about the feet, soften the epidermis and facilitate cleansing. In addition to a descending shower, a movable spray or horizon-

tal jet may be advantageously provided for the better cleansing of the axillæ, genitalia and perineal region. The warm bath should always be completed with a cold shower, to contract the cutaneous capillaries and better protect the individual against those forms of disease so largely favored by atmospheric conditions or changes.

As is the case also with lavatory basins, there is no definite ratio in our service between the number of men present for duty and the amount of bath apparatus to be supplied. At present, in the plan of barracks now being erected, three shower baths and three or four tub baths are supplied to each company. In the British army only one bath tub is provided for each hundred men—a fact which, combined with the lack of heated water, results, according to Evatt, in the practical discontinuance of bathing by the British soldier between the middle of October and the middle of April. For a temperate climate one shower bath to each twenty soldiers should be the minimum; a larger number of tub baths, if they are in use, being required. For stations liable to have a fluctuating strength, as at recruiting stations, the bathing facilities should be proportioned to the greatest authorized capacity of the barracks. This would avoid any such conditions as occurred at Columbus Barracks in 1898, when, owing to an influx of recruits, it was reported that, even with all the tubs in the bath-house in use night and day, it was impossible to secure a bath for each man as often as once a week.

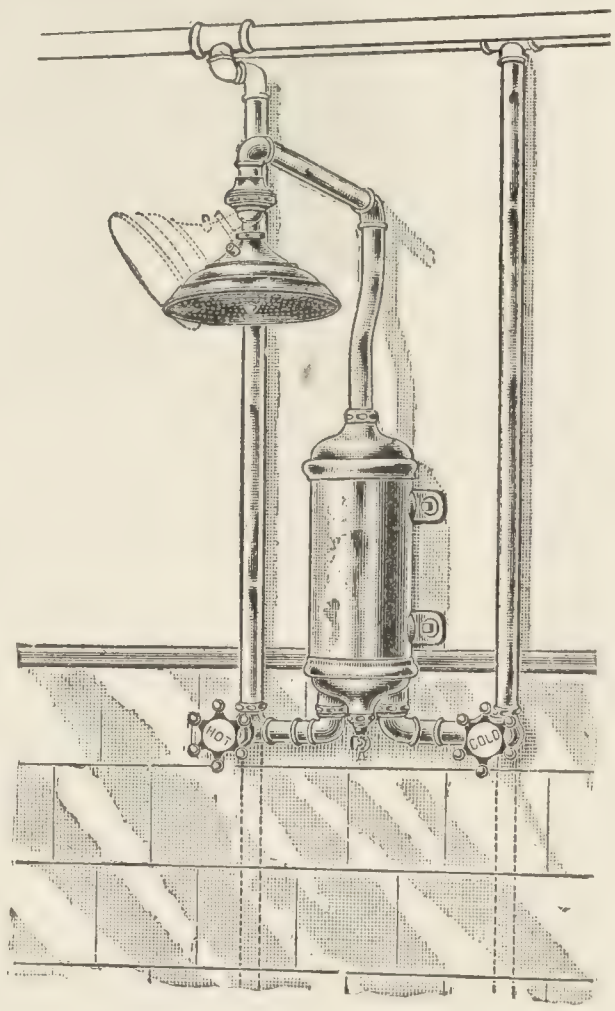


FIG. 307.—Clow Shower Bath, as Used in the United States Army.

Rain-Bath Systems.—In its simplest form, the rain bath consists in a rose nozzle placed at an elevation of seven to ten feet, perforated by a large number of fine openings and supplied with a stream of tempered water slightly above blood heat. A primitive and economical bathing system which, according to Viry, is still continued in certain of the French barracks, consists in heating water in a large kettle on top of an ordinary stove. The warm water is then mixed with cold in proper proportions in a tank or tub and is raised by an ordinary hand pump to the sprinkling apparatus which serves to shower the men.

In the United States military service two quite dissimilar forms of shower apparatus are in use—the Clow and the Schaffstaedt systems.

The Clow shower bath, shown in the accompanying illustration, uses a mixture of hot and cold water, these being passed into a mixing tank before reaching the bather. The supply pipes are run along the upper portion of the wall in order to avoid the necessity of piercing the floor, with the resulting interference with efforts at cleanliness and ever-present possibility of leakage. This system, of an inexpensive character, is being

installed in all the army posts now in course of construction. To ensure the uniform and proper temperature of the water, and to avoid the waste of time which results when each soldier adjusts the temperature of his own bath, it would be well to supply all showers from a single boiler in which the contained water is maintained at a constant degree of heat. This is readily accomplished by the use of an internal steam coil, provided with an automatic valve, by which the supply of steam is cut off as soon as the water reaches a certain temperature. Such a tank requires an occasional cleansing if the water used be hard, a special opening at the end being provided for this purpose.

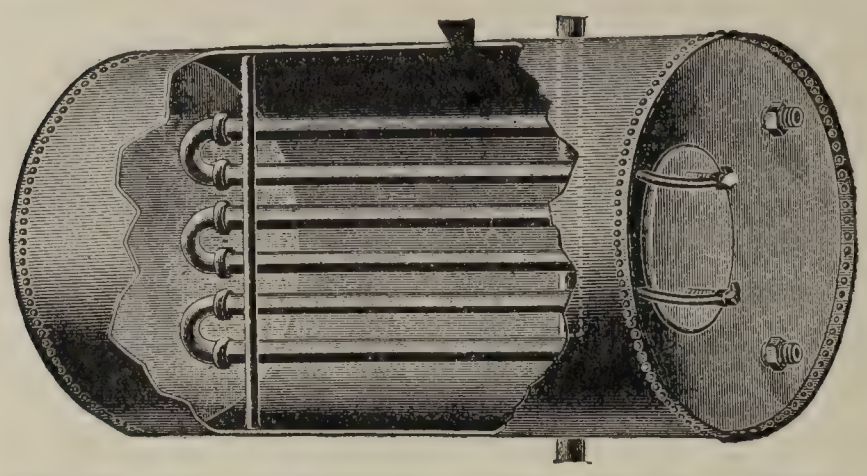


FIG. 308.—Tank for Maintaining Warm Water at a Constant Temperature.

The Schaffstaedt patent rain-bath apparatus is in use on various army transports and is also extensively employed in the German military and naval service. As the system requires the use of steam for heating purposes, its connection with an existing steam plant or the installation of a special boiler—not necessarily expensive in character—is necessary. The working principle consists in causing water and steam to flow in opposite directions, but in such a manner that they do not mix. As is shown in the accompanying vertical section of the apparatus, the steam enters the tube in the body of the apparatus through the steam pipe *b* and the steam valve *g*, passing out at the lower end at *c*. The water enters at *a*, and rising past the descending steam is warmed by the latter. It then passes through the water valve *f* and pipe *d* to the overhead douche *e*. The steam, descending noiselessly, parts with all its heat and is discharged at the bottom of the apparatus condensed into water, its temperature being about the same as that of the cold-water supply. By turning the handles *f* and *g*, the water and steam valves are opened together, wide enough to secure the desired temperature of the water as indicated by the thermometer. The temperature can be regulated by the steam-valve *g*.

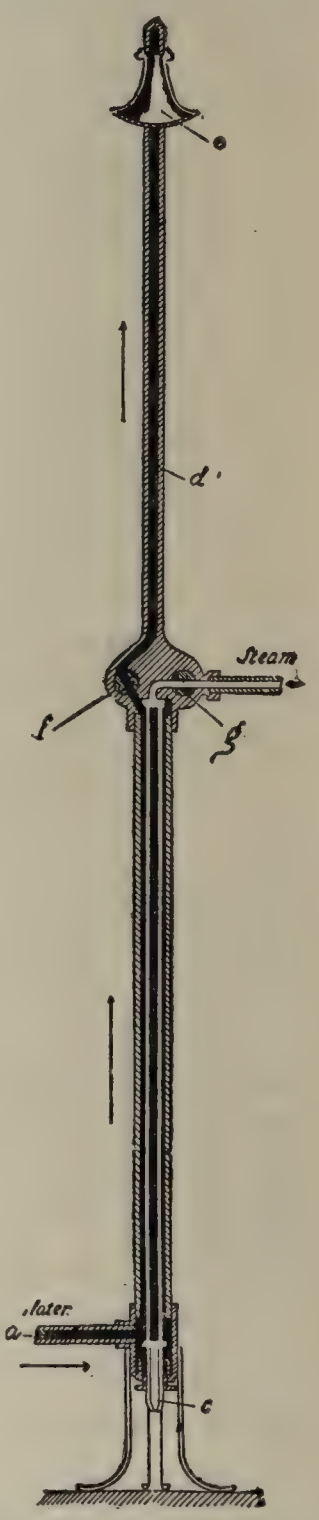


FIG. 309.—Sectional View of Schaffstaedt Apparatus.

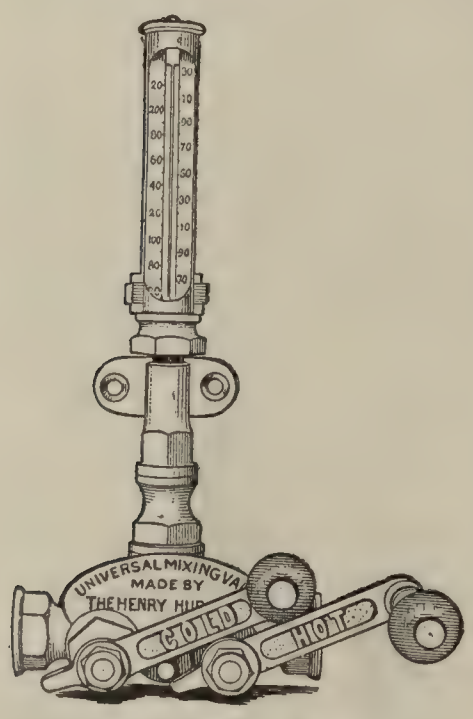


FIG. 310.—Universal Mixing Valve.

The Universal mixing valve is especially ap-

plicable to the Schaffstaedt apparatus. With its use the turning on of hot water without at the same time establishing the flow of cold water is impossible, even with handling by inexperienced persons, and hence the danger of scalding is avoided by the bather.

The capacity of the apparatus must be proportioned to the number of douches on each warm-water supply line and the water and steam press-

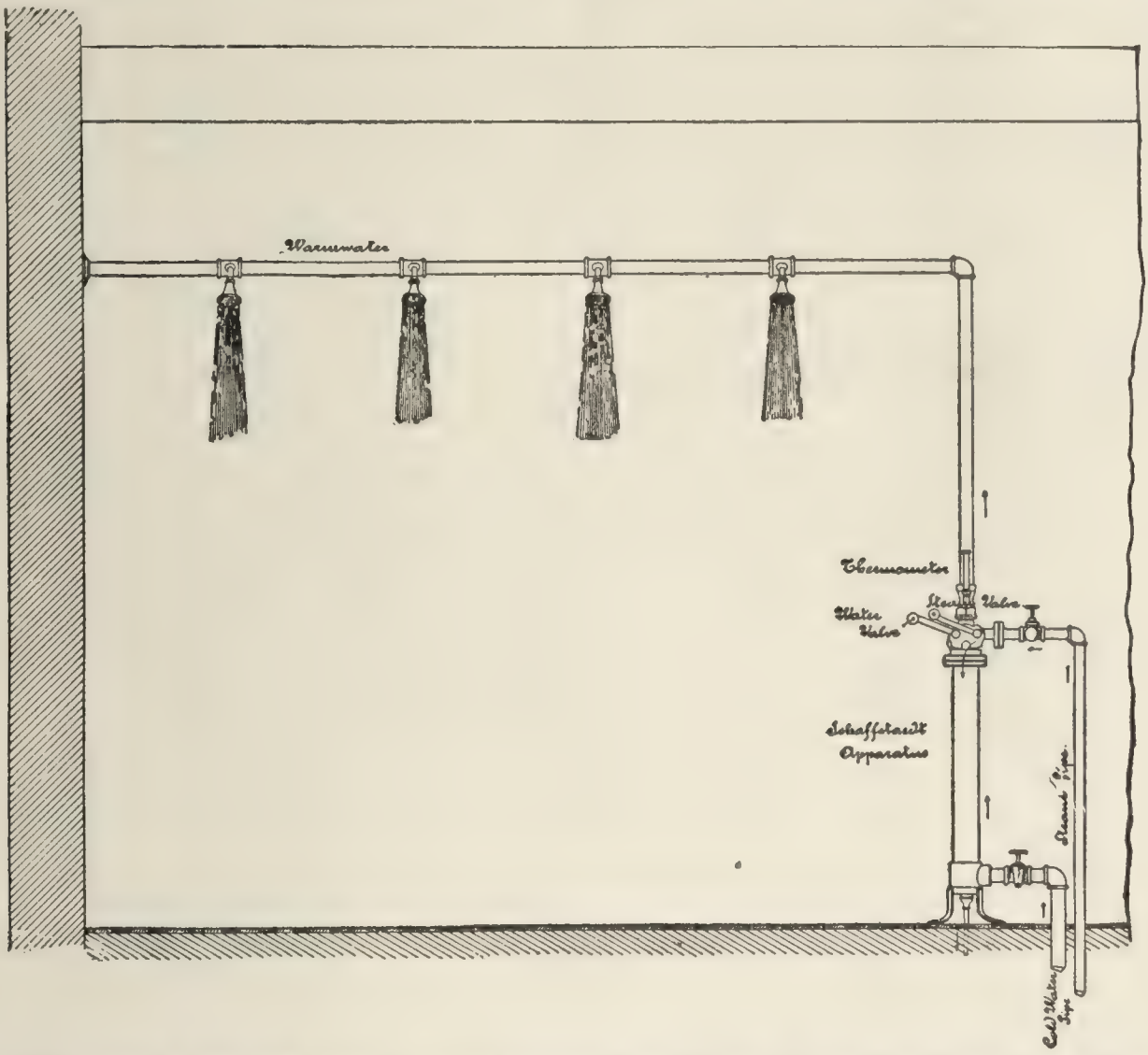


FIG. 311.—Detail Showing Row of Douches Supplied from a Single Large Schaffstaedt Apparatus.

ures should remain constant. In its use a non-commissioned officer preferably operates the valve, determines the temperature of the water by reference to the attached thermometer and controls the length of time during which the douches are in operation. At the end of the bath he gradually lowers the temperature of the water by slowly turning the handle of the steam valve, a procedure which does not affect the water pressure.

This system is specially applicable to the transport service, since steam of a certain pressure is always available and sea-water can readily be pumped up and heated by the apparatus for use for bathing purposes.

Post Bath-Houses.—It is essential that bath-houses be kept neat, scrupulously clean and inviting in appearance, and that they be well heated, properly ventilated and amply lighted.

While the better class of flooring for bath apartments is made of vitrified tiling, equally good results are given by floors of artificial stone, fin-

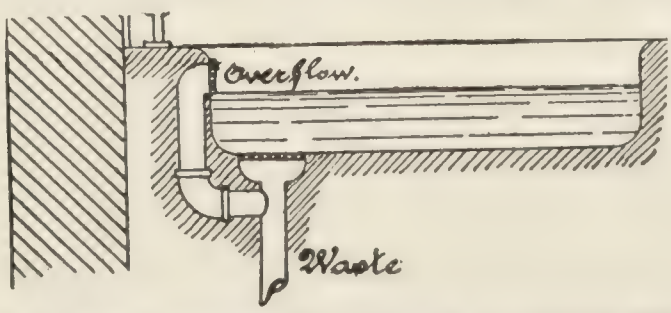


FIG. 312.—Vertical Section of Basin in Bathing Cell with Shower-Bath System.

ished off with cement. Asphalt is impervious to moisture and is said to be somewhat more agreeable to the feet of the bathers. The floor should be graded so as to be drained by one or more waste pipes. To afford better facilities for cleansing the feet, the flooring under each shower should be slightly depressed. The resulting basin, of several inches depth, may be moulded in concrete and provided with a standing over-flow or with an adjustable strainer over the drain, so that the water does not escape quite as rapidly as it is delivered. The walls and partitions should be finished off with some non-absorbent material, such as enamel-faced brick or corrugated galvanized iron, painted with several coats of enamel paint. Partitions should be raised about twelve inches from the floor to facilitate its cleansing and promote the circulation of air. The height of the dividing partitions should be not less than seven feet to ensure privacy.

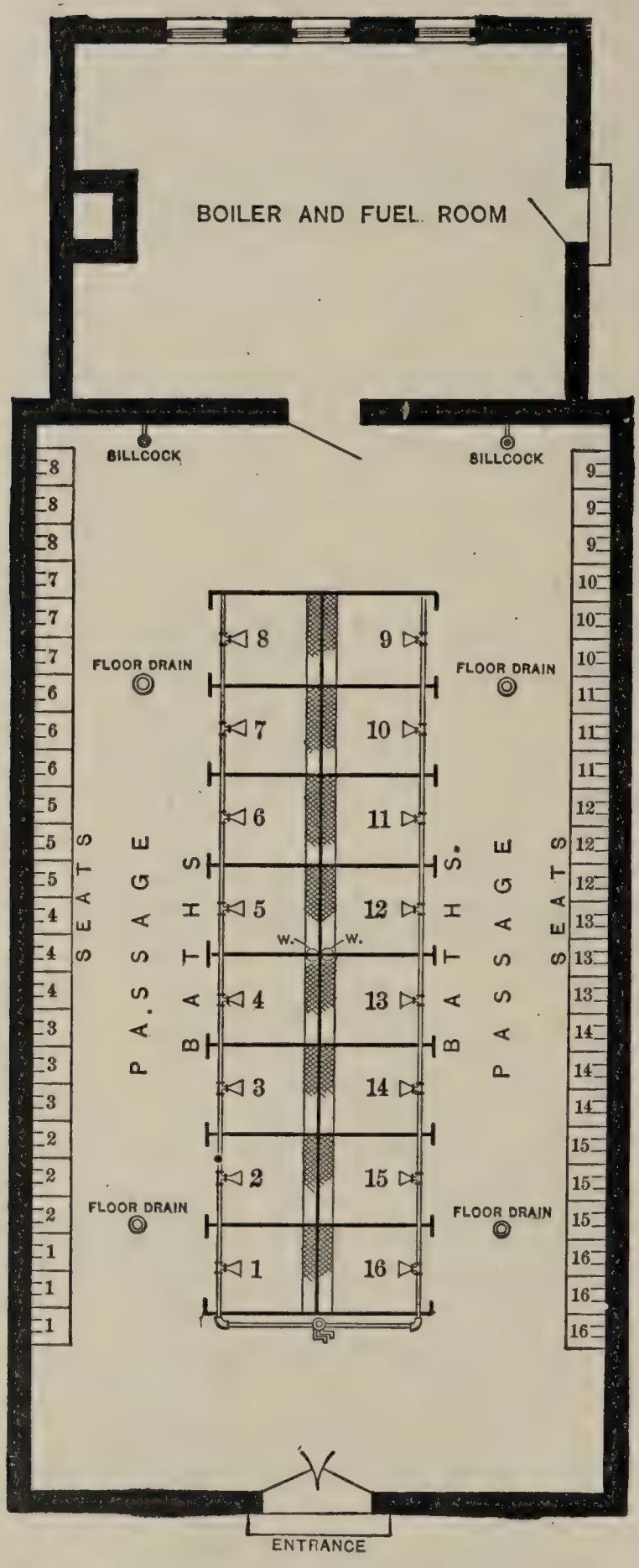


Fig. 313.—Plan of Bath-House for a Regimental Post.

For bath cells, in the military service, no furnishing other than a perforated soap cup and a hinged seat should be provided. All plumbing should be durable, plain but substantial, and perfect from a sanitary standpoint. All waste pipes should be so proportioned as quickly to remove all soiled water. To prevent splashing and afford privacy, a small curtain of washable material may be hung up in the doorway of each compartment, but usually this is not desirable.

The accompanying diagram shows the plan of a bath-house adapted to the military service, as used in the German army, and of ample size for the needs of a regiment. The room contains two rows of eight baths each, or sixteen bath apartments, centrally arranged. On each side wall there is a row of twenty-four seats, with overhead clothes-hooks, affording a total seating capacity of forty-eight. There are three times the number of seats that there are bathing cells. The latter are numbered and three ad-

joining seats are given the corresponding number. After the first sixteen men are undressed, they occupy the sixteen compartments and, while they bathe, the second squad of men occupies the second set of seats. When the first squad leaves the bath to dress, the second set takes its place in the baths and the third detachment occupies the third set of seats and begins to undress. When the second squad leaves the baths to dress, the third squad takes its place, the first squad leaves the bath-house and a fourth squad enters and prepares for bathing. It will be seen that such an arrangement permits of the rapid bathing of a large number of soldiers.

The capacity of such an establishment, provided three squads are bathed per hour, is 480 baths per day of ten hours. The size of the bathing hall is about 25 × 50 feet, but may be modified to suit local conditions. The level of the corridors is slightly raised to prevent their wetting when baths are being taken. If the floor of each cell is not depressed to form a basin, it should slope so as to discharge into a common gutter, with

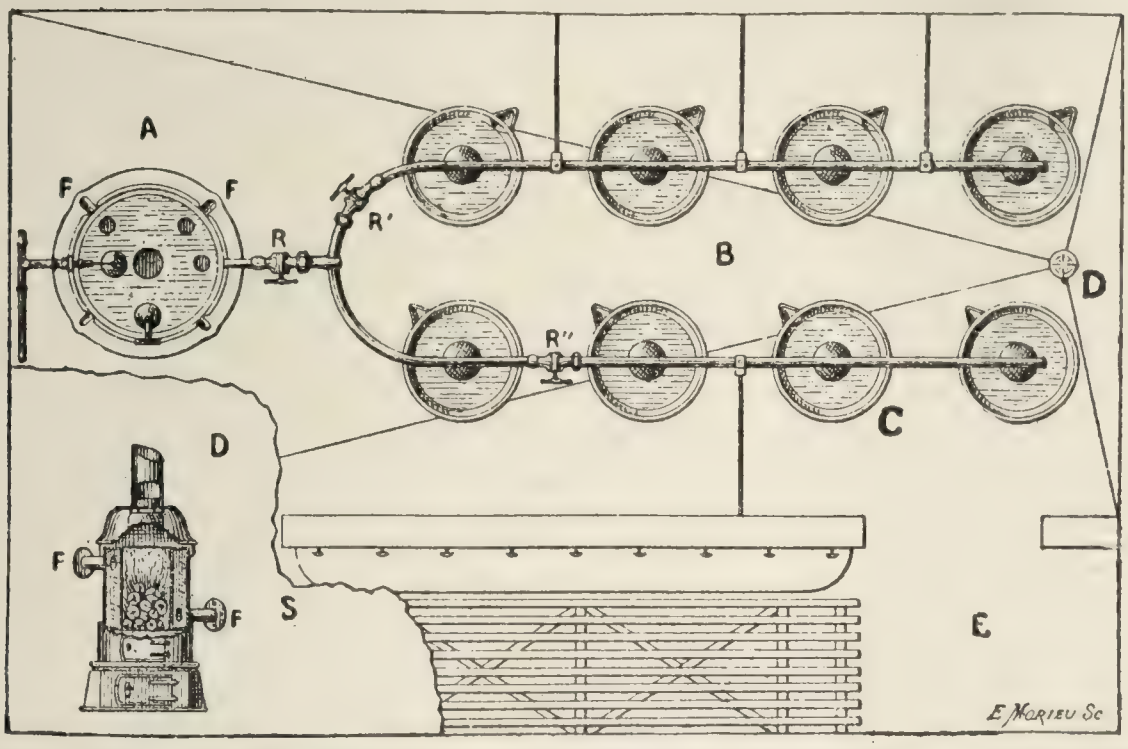


FIG. 314.—Ground Plan of the Shower-Bath System as Used in the French Army. *A*, Water heater; *B*, distributing Apparatus; *C*, tubs; *D*, drain.

perforated cover. It would seem necessary that such a bath-house should be provided with a urinal, to avoid the possible perpetration of nuisances by the men while bathing.

In the German army the lavatories and baths are in separate buildings detached from the sleeping quarters. This plan is excellent and should be followed in our own service. It is true that detached lavatories, bath-houses and latrines are in use in some of our garrisons, as illustrated in the preceding chapter, but their employment should be extended to all posts and under all conditions. To put plumbing of any sort in a barrack building is a mistake; and where a lavatory and bath-room are in the basement of a barrack, this basement is necessarily damp and close. It is by attention to such minor details that the sick-rate can be lowered in the future.

The Care of the Person in the Field.—The results of uncleanliness during campaign have been graphically portrayed by Smart, as follows: "Nor was positive disease lacking as a consequence, for the irritation of the skin caused by the heat, perspiration and the contact with dirty underclothing, hardened by moisture, organic elimination and epithelial

débris from within and dust and all manner of uncleanliness from without, led to papillary inflammation, accepted in its milder form as 'prickly heat,' but which, in cases aggravated by the nails of the individual and the browsing of pediculus corporis, became erythematous, eczematous and finally formed a special disease known as camp eczema or camp itch. The amount of suffering and loss of sleep from various degrees of this condition did much to impair efficiency, irrespective of loss from men absolutely driven to hospital for relief. The disgust with which persons of cleanly habits regarded themselves and their neighbors, when more or less affected in this way, was often productive of low spirits and home-sickness."

The maintenance of personal cleanliness in the field depends to a large extent upon the energy and desires of the soldier, for much may be done in the way of cleansing the body even with meagre facilities. During active service, every possible attention should be given to cleanliness of the body, and marching troops should be required daily to bathe the arms, genitalia and feet in the prevention of chafing, balanitis, pruritus and excoriations. Cold swimming-baths, in river, lake or sea, serve an excellent purpose as regards cleanliness, and their use should be favored whenever time, place, circumstances and season permit. It should not be forgotten, however, that severe chills may follow immersion in cold water by such individuals as may be suffering from malarial infection. If the supply of running water available for bathing is small, a hole may be dug in the bed of the stream and allowed to fill, or a small dam may be constructed. Sponge baths are always available and are of great value during campaigns. They are best taken by spreading the rubber blanket over a broad, shallow excavation in the ground and thus forming an improvised bath-tub. The contents of two or three canteens of water poured into this rubber tub suffice for the attainment of excellent results as regards cleanliness, while a wet cloth admirably takes the place of the sponge. Where actual bathing or washing of the person is not practicable during field service, the body should be rubbed, morning and night, with a damp towel. Some soldiers habitually wash themselves thoroughly after arrival at camp at night, contenting themselves with scanty ablutions before beginning the day's march. It is well to remember, in this connection, that the use of strongly alkaline water, particularly when associated with exposure to the dust of the march and the rays of the sun, has a marked effect in producing roughness and soreness of the skin and cracking of the lips. Habits of carelessness as to personal cleanliness, of a more or less permanent character, may be induced through the lack of facilities for washing and bathing during a long campaign, and such are of course to be opposed in every way.

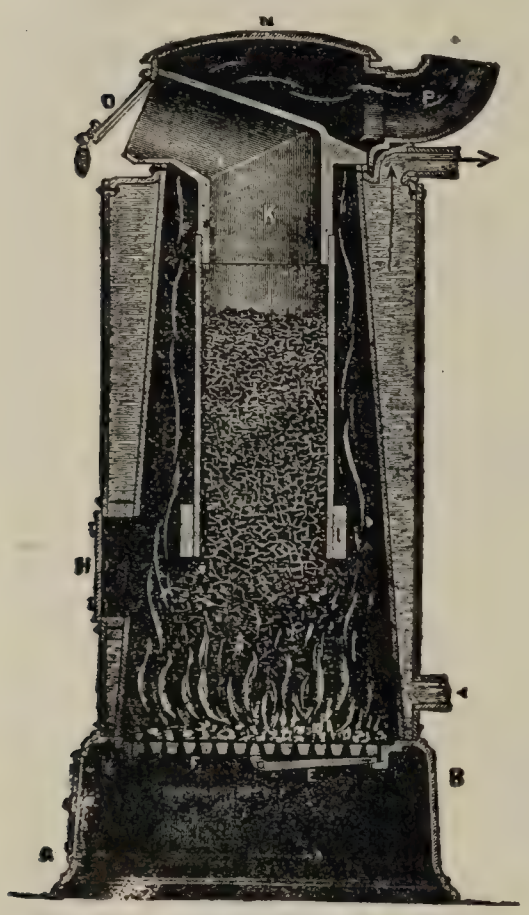


FIG. 315.—Tabasco Water-Heater.

In summer camps, when the ablutions can be performed in the open air, excellent arrangements for a lavatory and for shower baths, in the presence of a piped water-supply, can rapidly and economically be made; such arrangements well repaying the slight labor and expense involved by the increased comfort thus afforded troops. In winter, however, both shelter and warmth must be provided, and it is evident that in temporary camps during cold weather the bathing of the entire person can rarely be properly accomplished — particularly since the water-supply under such circumstances is usually scanty, or, if sufficient, there is lack of means properly to utilize it. In winter quarters, during the Civil War, a hot-water supply was often extemporized by fitting a camp kettle with circulation pipes connected with pork barrels, the warm water being drawn off from the latter as required. The Tabasco water-heater is simple in construction, easy of manipulation and moderate in cost. The average size is capable of heating 300 gallons of water per hour. Where obtainable, it would serve an excellent purpose in connection with the camp bath-house.

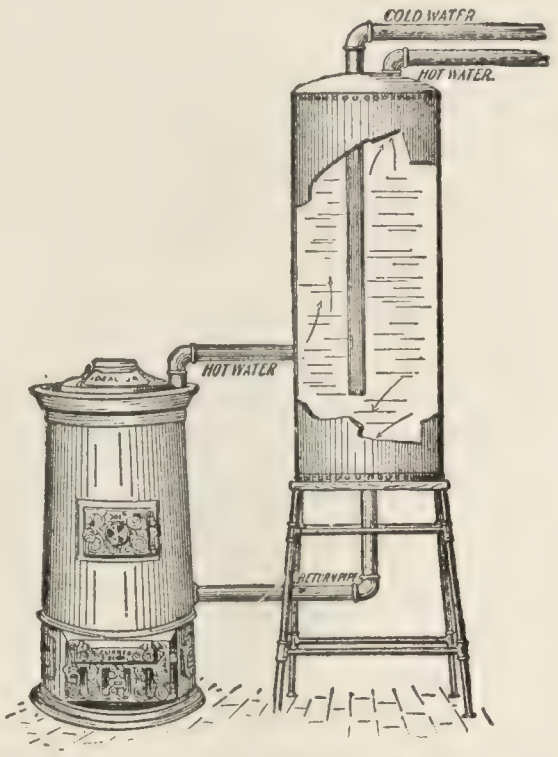


FIG. 316.—Diagram Showing Simple Arrangement for Obtaining a Hot-Water Supply in Camps.

In camps of a semi-permanent character, an early and imperative duty consists in the erection of suitable structures for use as wash and bath-houses, equipped with facilities for the supply of a limited amount of hot as well as an abundance of cold water and with proper provision for the removal of all waste. Wherever a piped supply of water has been laid, rough buildings, containing a number of stalls for shower baths sufficient to meet the needs of a regiment, can be constructed at a cost of about $200 each. The water may be heated by passing it through a coil of pipe built into a brick fireplace, cold water being admitted into the main channel through another pipe. The floor, constructed of cement, should drain into a temporary sewer, or, if no better arrangement be possible, into a stoned or cemented gutter discharging into a covered and ventilated cesspool located at some distance. For a bath-house in winter quarters, the plan suggested by Billings some years since, for use at frontier posts, serves excellently.

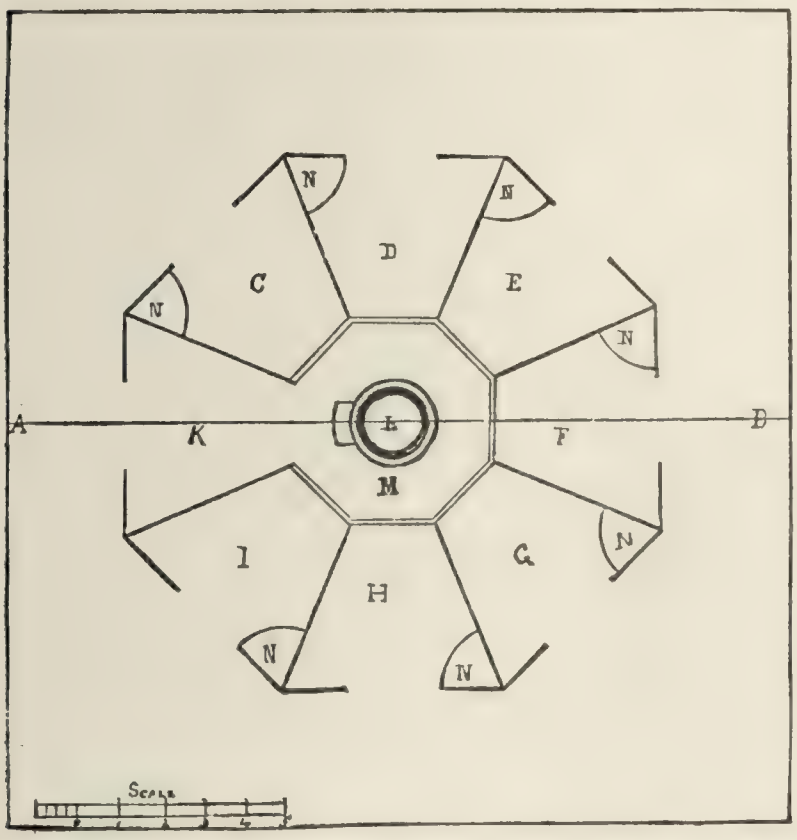


FIG. 317.—Ground Plan of Bathing Cells as Proposed by Billings.

In this plan a series of bathing cells (C, D, E, etc.) surrounds a central space, containing a stove and hot-water tank (L) and separated from it by a latticed partition to admit of the reception of heat. One cell (K) is left incomplete to allow of entrance to the stove. The cell floors slope downward and inward one inch to a common drain. The dimensions proposed were as follows: The central space to be 5 ft. in diameter; the bath cells 4 ft. 6 in. deep, 5 ft. 3 in. across widest end, and 6 ft. in the clear; doorways to be 2 ft. wide and 6 ft. 6 in. high.

For officers in the field, an excellent arrangement for securing shower-baths consists in carrying in the equipment a small rose-nozzle, such as is commonly supplied with modern bath-tubs, to which is attached several feet of rubber pipe of small caliber. A bucket of water of the proper temperature having been secured, the rubber pipe has a stone or weight attached to its free end and the whole is immersed in the water. It is then pinched at both ends, while the rose nozzle is carried over the rim to fall below the level of the water in the bucket. Siphonage at once begins, and the bucket may be hauled up to a sufficient height by a bit of tent-rope or halter-strap passed over the ridge-pole of the tent or a convenient bough. The rubber blanket is stretched beneath the bucket over a shallow excavation, as already suggested in connection with the sponge bath. Outside the bucket, which can generally be obtained in camps where there is any wheeled transportation, the necessary apparatus does not weigh more than three or four ounces in all.

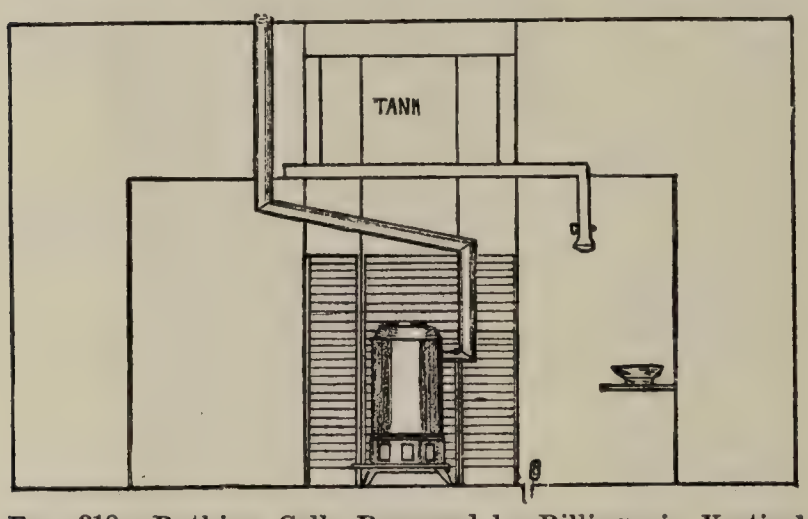


FIG. 318.—Bathing Cells Proposed by Billings, in Vertical Section.

The Care of the Feet.—The care of the feet has been to some extent discussed in connection with the conduction of the march; the maintenance of cleanliness being of the greatest importance in ensuring their integrity during campaign. The skin of the feet is particularly rich in sudoriparous glands and is subject to abundant exfoliation of the epidermis. The fetid secretions, confined by the coverings of the foot, soften the cuticle and render it, in the absence of proper cleanliness, more sensitive to pressure and friction. Particularly in warm weather is the lack of proper attention to the feet a source of cutaneous irritation. The application of water does not make the skin tender, but on the contrary hardens it, and, by promoting local nutrition, assists in preventing the occurrence of blisters, corns and callosities.

Cleanliness of the feet of the men is a matter to which company officers should give their careful attention; a daily foot-bath being under all circumstances desirable, in garrison as well as on the march. Proper facilities for foot-baths should always be available in connection with the company wash-room; if not officially provided, they should be improvised. Men should be instructed to cut the toe nails squarely across, not rounded and not too far behind the end of the toe. Removal of the corners has a strong

tendency to promote ingrowth of the nail, particularly with too narrow shoes. Hard corns, if painful, may be shaved down with a sharp knife or scraped with a piece of broken glass. Soft corns, between the toes, should receive several applications of a saturated solution of salicylic acid in collodion; when, after soaking in hot water, the corn can be readily extracted *en masse*. The same procedure is also effective with respect to hard corns. It has recently been proposed to require the company barber to look after the feet of the men in his organization, after a preliminary course of instruction by the medical officer. This is an innovation which would undoubtedly be productive of good results if its details were properly carried out. At present, the care of the feet receives too little consideration in our service. Great attention is paid in the German army to this matter, and it is required that the feet of each man shall be inspected by one of his company officers, a medical officer and the *Lazarethgehülfe*—corresponding to our hospital steward—at least twice a week in barracks and oftener in active field manœuvers. The method of making this inspection is to form the companies in squads, standing upon tables or benches sufficiently high to bring the feet directly under the eye of the inspecting officer and to bring under his observation any wincing or flinching when the inspected man jumps to the ground barefooted. The inspecting officer passes down the line, carefully examining the front of the feet and legs, which are bared to the knees, searching for strained tendons, blisters, improperly cut nails or untrimmed corns. Having passed down the line, the men are about-faced and the tendines Achillis carefully examined; and the soles are inspected as they raise one foot and then the other. As a man passes from the table or bench, he leaps to the ground and runs to his shoes and stockings. This is to show any bruised soles or periostitis of the tarsus. Any case of blisters, improperly cut nails or tendo-synovitis are at once cared for by the *Lazarethgehülfe*. More serious disorders are sent to quarters or hospital.

At the same inspection each man's socks or "*fuss-lappen*" and boots are carefully examined as to their condition of cleanliness. As the German infantry regiments average in marching a kilometer in ten minutes, being often pressed to a kilometer in from seven and one-half to eight minutes, each man carrying sixty pounds, this care of the feet is most necessary. When tables or benches are not available, the trunk of a fallen tree or a block of stone is made use of for the foot inspection.

The Care of the Mouth.—Broken or carious teeth considerably impair the efficiency of the soldier. Besides exposing him to the liability of odontalgia, alveolar abscess and periostitis, the possession of such teeth implies an impairment of the powers of mastication which, with the use of the hard ration of the field, may often induce intestinal disturbances and diarrhœa. Soldiers who are affected with foul or diseased mouths are annoying, if not actually dangerous, to their comrades; their fetid breath being a powerful factor in the pollution of the atmosphere of the tent or squad-room, while the saliva of such cases has been shown to contain an unusual proportion of pathogenic bacteria. Dental caries is much more common in certain races or localities than in others. Among our negro troops, even when no care whatever of the mouth is taken, the teeth are often observed to be clean and sound, without tartar or decay.

Ulcerative stomatitis has been common in armies, frequently becoming epidemic, although much rarer of late years. While this condition is undoubtedly to be regarded as primarily of scorbutic origin, the proper cleanliness of the mouth and care of the teeth may do much to prevent its occurrence or modify its severity.

Carious teeth should be promptly filled; both for their own preservation and to avoid the favoring of decay in their sound neighbors through contiguity. It would be much to the advantage of the service if dentists were provided by the Government to care for the teeth of men while in the field or at isolated stations. Tooth-brushes should be furnished by the Government as part of the equipment of the soldier, and their proper use in all instances required. In the absence of such official action, it becomes the duty of company officers to insist upon their purchase and regular employment by those under their command.

Usually the men themselves, especially the better class of soldiers, pay much attention to the care of the teeth, and it is undoubtedly the case that in our service the hygiene of the mouth receives far more consideration than is given it in foreign armies. Among our soldiers it is those of alien birth who are the most derelict in this respect; but careful oversight of the habits of all recruits is necessary.

Tooth-brushes should be used twice daily. They should be made of soft bristles and are not to be forcibly employed, as tending to render the teeth sensitive through mechanical retraction of the gums. The motion of brushing should always be in the direction of the teeth and never across their surface. In the German army, a weak solution of salicylic acid is to some extent employed as a tooth-wash, but for application to the teeth powdered chalk best answers all purposes. Wood ashes and wood charcoal make an excellent dentifrice and are frequently employed by soldiers for this purpose.

The Care of the Hair and Beard.—The hair of the soldier should always be kept short; not only to permit of the more ready cleansing of the scalp but to lessen the liability of infection by insect vermin and contagious skin disease. Long hair is the glory of a woman but the shame of a soldier. Wolseley recommends that the hair never be permitted to exceed half an inch in length during campaign, or be at any time so long that the soldier is enabled to part it. The head should be particularly well cared for while in the field, and should when possible receive a daily washing with soap and water. Brushing of the hair should be done at least once daily, and preferably prior to each meal.

For greater uniformity of appearance as well as for purposes of cleanliness, the wearing of the full beard is not desirable in the military service. Although during campaign the growth of full beards is often a matter of necessity, under such conditions they should be kept closely cropped by the use of scissors or clippers. In the army of the United States there is at the present time no restriction as to the growth of hair upon the face, provided that the beard, if worn, shall be neatly trimmed; but up to the outbreak of the Civil War a regulation was in force prohibiting the wearing of hair on the face of the soldier below the angle of the jaw. In the British military service, the Highland regiments are allowed to wear the full beard; while the flowing moustache was, in that service, long the dis-

tinguishing mark of the cavalryman. The Russian soldier is authorized to wear the full beard; but in the French army only the moustache or the so-called imperial can be worn.

An extensive epidemic of sycosis or "barbers' itch" occurred at Madison Barracks in 1898, the infection following the use of uncleanly razors and shaving brushes. It is well known that ringworm, favus, certain eczematous eruptions, seborrhœa, syphilis and other diseases may also be readily transmitted through the agency of the company barber; his instruments usually serving as the means through which the infection is accomplished. Hence all barbers in the military service, before being authorized to ply their trade among troops, should receive instruction from a medical officer in the general hygiene of the hair, beard and skin, and should thoroughly understand the technique required in the sterilization of brushes and instruments. Permission to continue the practice of their calling should depend upon the maintenance of scrupulous cleanliness, both of the hands and instruments; while they should be required to refuse to serve and report at once to the medical officer such cases of possibly contagious skin affection as may come under their observation. Greases or emollient preparations of inferior quality and injurious properties should not be employed. The disinfection of shaving-mugs, scissors, clippers, razors and brushes may be accomplished by chemical solutions or boiling water. Heat damages the temper of razors, hence they are best disinfected after each use by immersion in a solution of tricresol, of one per cent. strength, for five minutes. Brushes may be cleansed by the use of water of ammonia or borax in solution. They are, in practice, preferably disinfected by immersion in a 1–1,000 solution of mercuric chloride. Such hair-brushes as have inadvertently been employed on cases of tinea, favus or similar disease should, however, be preferably destroyed by fire. Powder-puffs and similar articles, such as cannot be treated with aqueous solutions without injury, may be disinfected by the use of absolute alcohol. The application in common of alum or magnesia, in solid form, should be prohibited. When used, they should be applied with a clean towel in the form of a fine powder. After finishing with a customer, the hands of the barber should be carefully washed and all bits of hair should be collected and destroyed, preferably by fire.

Insect Parasites.—Destruction of head or body lice, a simple matter in camp or garrison, often becomes a difficult problem during active campaign. If the head becomes infested, the hair should be closely trimmed and receive frequent and thorough shampooing, followed by the washing of the scalp with a 1–2,000 solution of mercuric chloride. This solution should contain a small amount of vinegar to loosen the nits from the hair. In the absence of opportunity for the accomplishment of the above treatment, careful use of the fine-tooth comb gives good results. On prolonged campaigns it may fairly be questioned whether such a comb should not form part of the personal equipment of the soldier. While mineral oil is an efficient parasiticide, its use in the hair for such a purpose is not advisable; since a number of cases have occurred in which its application to the scalp, accompanied by friction, has resulted in apparent spontaneous combustion and fatal burns.

According to Woodhull, infested clothing may be freed from insect vermin by soaking it in a barrel of water containing a handful of "fish ber-

ries" (Cocculus indicus). Sabadilla powder, dusted freely along the seams of garments, will destroy the pediculus vestimentorum; but its use must be frequently repeated, as it has no effect in preventing the hatching of the eggs of the parasite. The powdered seeds of the stavesacre (Delphinium staphisagria) have long been used for the destruction of lice. During the Civil War, infested clothing was commonly turned inside out and the seams were carefully gone over by hand for the destruction of lurking insect life. To prevent a return to this favorite retreat, the inside seams were subsequently greased with blue ointment or with the ointment of the nitrate of mercury. The destruction of the "nits," as well as of the body lice themselves, may be speedily accomplished by the thorough boiling of the infested garments, preferably in soap-suds or weak soda solution. Boiling water, however, is with difficulty obtained in the field for other than cooking purposes, and hence the destruction of vermin by this method is only rarely practicable during active campaign. In garrison or where a steam sterilizer is available, the use of this agent is followed by satisfactory results, save in respect to the resulting shrinkage of woolen garments.

Men of the most careful and cleanly habits are liable to infection with body lice through inadvertent and often unavoidable contact, and the infested person of a single slovenly individual may be the means of the introduction of annoying parasites throughout an entire command. The early detection of such vermin, with prompt application of measures looking to their destruction, is of the greatest importance in the prevention of their dissemination among troops.

Infection with the pediculus pubis, or crab-louse, is not usually brought about or favored by military conditions. A daily toilet of the genitalia will do much to prevent the continued existence and multiplication of this parasite. The remedy is shaving of the parts with the application of mercurial ointment, together with proper measures directed to the clothing of the individual affected.

During the Civil War, parasitic skin diseases were extremely common and assumed an unusually severe character; 32,080 cases being diagnosed as "itch," while 35,667 cases were merely recorded as "skin disease." The pathology of the affection known as "army itch" was much disputed at the time, but sulphur, sulphide of lime, kerosene oil, and similar remedies of known value in the treatment of scabies appeared to have been successful in bringing about its termination. At the present time, scabies is far less prevalent among our troops than in those of the various European powers. The average annual number of cases of scabies occurring in the United States army, for the decade 1885–1894, was 21.1; but there has been great improvement in this respect in recent years. In 1895 there were 12 cases of this affection, in 1896 there were 10 cases, while in 1897 only a single case was reported—showing the practical results of the greater attention latterly paid to personal cleanliness in our military service.

Cleanliness of the Clothing.—The washing of the clothing of the enlisted man in the United States army is left entirely to the discretion of the individual and is not under any direct military control. At present, such persons as may do the washing for troops have no official status; but company laundresses, in the proportion of four to each organization,

were formerly officially recognized in the military establishment, were paid for their services and were given allowances in the matter of rations, quarters and fuel. These laundresses were appointed by the company commanders, and were usually, though not necessarily, the wives of enlisted men belonging to the organization to which they were attached. The system was preferable from a sanitary standpoint to that now in use, since it placed the washing and laundrying of clothing under the immediate control and ready supervision of the military authorities. The act of Congress approved June 18, 1878, prohibiting women from accompanying troops as laundresses, and the subsequent restrictions placed upon the enlistment and re-enlistment of married men by army regulations and orders, practically did away with army laundresses and compelled the enlisted men to do their own washing or have it done outside the post. This seems inconvenient and unsatisfactory; and the introduction of duck clothing and linen collars adds to the expense, especially in southern latitudes. Some amelioration seems due the men in the active service of the Government, and the establishment of post laundries would solve a troublesome problem and prove a strong ally to contentment, cleanliness and appearance; and seems to call for special consideration, since the habitual method of doing laundry work in the tropics, in running streams and without boiling, increases the danger of certain cutaneous diseases. Where the laundry work is done in the present haphazard fashion, moreover, a soldier can plead the neglect of an irresponsible washerwoman as an excuse for his dirty linen and underclothing. The soldier is nominally at liberty to wash his own apparel should he so elect; but as a matter of fact, adequate facilities for the laundrying of clothing are not provided in barracks and he is perforce compelled to patronize such individuals, resident in or in the vicinity of the post, as can advantageously carry on such work; the usual monthly charge for this service being one dollar per man.

At Jefferson Barracks a large steam-laundry plant, under control of the Quartermaster's Department, was long in operation and in every way yielded eminently satisfactory results. It was, however, unfortunately destroyed by fire several years since and has never been re-established. Such steam laundries, for hygienic reasons as well as for convenience and economy, should be installed at all posts garrisoned by sufficient troops to ensure the payment of their running expenses. It is obvious that hygienic precautions can be more carefully maintained in a large central laundry establishment than where soiled garments are scattered at frequent periods among a large number of insanitary households, in which they are often improperly cleansed and are frequently themselves exposed to the danger of infection with the elements of disease.

Where steam laundries conducted by the Government would not be practicable, there is no reason why a large central laundry should not be established in each garrison and conducted under the management of the post exchange. The services of the women at present performing the work of laundresses could be hired by the new establishment; and thus all soiled articles could be thoroughly and promptly cleansed, under sanitary conditions and at a minimum of cost to the soldier.

In European armies, the barracks are supplied with an equipment of laundry apparatus; since the soldiers, by reason of their meagre pay, are

necessarily forced to wash a considerable proportion of their own apparel. Laundresses, in the proportion of two to each battalion, were long included in the organization of the French army, but at present, in that service, the washing of soiled clothing is done by contract and at the expense of the Government. Each company receives a monthly sum for this purpose, amounting to about ten cents for each soldier—but provision is made for the laundrying of only a limited number of articles and the excess must be washed by the man himself or be done at his expense.

In time of war, the laundrying of clothing for troops cannot be properly performed by the people among whom the war is waged, and hence during campaign each soldier must wash his own clothing. As the proper performance of the operation is something of an art, troops should have practical experience, prior to campaign, in the methods in which it is best accomplished in the field. Soiled body linen, when impregnated with sweat and dust, is irritant to the skin, favors the invasion and multiplication of insect parasites and emits mephitic odors—hence frequent opportunities for the purification of such articles will conduce greatly to the health, comfort and efficiency of troops in camp or on the march. Filthy surroundings or garments may readily neutralize all efforts for the maintenance of bodily cleanliness. Blankets, as well as underclothing, should be washed at suitable intervals—a matter intimately related to the cleanliness of the soldier, yet one too often neglected. It occasionally happens that through inattention on the part of company officers to the personal cleanliness of their men, their underclothing is worn until it attains a most filthy condition. Bodily cleanliness cannot be maintained under such conditions even if a daily bath be taken, and vermin can usually be traced to some such source.

The facilities for the laundrying of clothing in the field are usually of a most primitive character. Artillerymen frequently employ for this purpose the canvas horse-buckets available in that branch of the service, while a rubber blanket placed over a shallow hole in the ground, as already noted in connection with bathing, answers equally well. A stray barrel, partially filled with soap-suds, can be excellently utilized; clothing washed therein being secured to a rope and allowed to float in a running stream, if one be available, for several hours. The clothing should, whenever possible, be immersed in cold water for several hours before washing to soak out all soluble impurities. Water so employed is highly charged with organic matter and micro-organisms; Miquel estimating that each cubic centimeter of such water contained, on an average, 26,000,000 bacteria, where ordinary sewage contained only 6,000,000. It is obvious that such water should never find its way into a source of supply, nor should it be thrown upon the ground in the vicinity of camps. Boiling, from the hygienic standpoint the essential part of the operation of washing, is necessarily omitted during campaign. After the preliminary soaking, the garments are soaped, rubbed, rinsed and hung up or spread on bushes to dry.

Woolen articles, to prevent shrinkage, should be washed in cold water without the use of much soap or of unnecessary manipulation and should be dried without wringing. In the absence of washing, woolen clothing may be cleansed by drying in the air and sunlight, followed by a thorough shaking and beating. Changes of clothing, treated in this manner, should

be worn on alternate days. The results given by this method are second only to those of actual washing.

In the washing of clothing a certain proportion of soap is said to be with advantage replaced by petroleum. This method is habitually practised in the armies of Russia and Germany, and has recently been adopted in various military hospitals throughout Europe. It is claimed for the process that cleansing is rendered easier, clothing suffers less deterioration and is made much whiter. The usual proportion employed in foreign armies is one gram of mineral oil for each liter of soapsuds used.

The washing of clothing becomes a much more simple problem if the camp be located upon a water-course; in which instance a special place should be set aside for laundry purposes, below the sources of water used for cooking and for the watering of animals. In time of epidemics, especially of cholera or typhoid fever, the washing of clothing in the field becomes a particularly serious sanitary problem, since even a small stream may transport infectious micro-organisms over a long distance and induce outbreaks of disease in villages far down its course.

In conclusion, it may be remarked that the maintenance of cleanliness of the person and apparel of the soldier demands constant watchfulness on the part of company officers. Individuals of careless or slovenly habits are usually recruits, and if among old soldiers they will generally be forced by the latter to take measures looking to proper cleanliness of body and raiment. While soldiers are, as a rule, quick to appreciate the value of cleanliness of the person and clothing, and to take prompt advantage of such opportunities as are afforded for its attainment, it is advisable that company officers frequently satisfy themselves by personal observation as to the proper condition of the more indolent. As expressed by Woodhull, "it is not sufficient to see that the arms are bright, the clothing spotless, or the bedding neatly rolled. Dirt that is hurtful is not the mud of the highway or field, nor the dust of the parade caught on the outside of the shoes and clothing; it is the cutaneous débris, mingled with dust and dissolved in perspiration, soaked into the underclothing, organic dirt that offends the nose as well as the eye, that depresses the subject and may poison his comrade."

CHAPTER XIV.

MILITARY MORTALITY AND MORBIDITY.

Broadly speaking, the main causes affecting the health of troops are the manner of living, the environment and the food supplied. The first relates to the occurrence of overcrowding, imperfect ventilation, want of cleanliness and inattention to personal hygiene. The second is typified in the accidents arising from atmospheric or telluric influences, such as rapid death from heat and cold, the comparatively transient influences of the seasons and the slower and more durable effects of climate as modifying diseases of a restricted habitat. The last cause concerns the diseases brought about directly or indirectly by vicious alimentation. Beside these, other influences of a less apparent but scarcely less potent character operate to affect the health, and consequently the efficiency, of armies. These act as predisposing rather than exciting causes of disease, and have special relation to the vital resistance of the soldier as affected by race, age, length and character of service, the fatigue and hardships of campaign and other factors. Some of these predisposing causes, in fact several of the most important of them, can readily be removed and thus prevented from contributing so materially to military inefficiency. With respect to others, sanitary science possesses no means for their elimination or avoidance and can at best merely endeavor to modify their effects; but since no precautionary measures are capable of entirely neutralizing their results, they must be considered as more or less inevitable in their character. Operating insidiously as these various predisposing factors do, they have not received in the past the consideration which their importance warrants, and a study of their influence upon the rates for sickness and death among troops is well worthy of the attention of the military sanitarian. These latter points it is the purpose of the present chapter to discuss.

Army Medical Statistics.—For a better understanding of the following subject matter, a brief consideration of army medical statistics, considered both as a whole and separately, is of importance. Their purpose is to define the influence of military life upon health, and to permit the ready appreciation and accurate comparison of varying conditions of service and environment in their relation to the well-being of the soldier; hence a knowledge of their composition is important to the sanitary officer. Since each case of sickness in the military establishment at once becomes a matter of official record at the hands of competent observers, it follows that statistics so obtained are not only more comprehensive but more accurate than those bearing on the occurrence of disease among civilians. Unfortunately for their general utility, however, they are based upon a physically superior class, always existing under restricted and unusual conditions and frequently in unfavorable surroundings, and hence deductions which may be drawn from them cannot be legitimately applied out-

side the limits of the military service. Unfortunately also, owing to the different systems of nomenclature and classification of diseases which have prevailed in the past, as well as to other causes which will be referred to later, it is not always possible accurately to compare the sickness and mortality from special causes occurring in different armies, or even for the military establishment and civilian classes of the same nation. The committee on international military medical statistics which met at Budapest in 1894 has, however, formulated a plan which overcomes in great measure the difficulties with which army statisticians have had to contend, leads to a common basis of comparison and will ultimately be the means of affording a large amount of information hitherto not available.

In the British army, statistics with regard to sickness and mortality were first compiled shortly after the close of the Peninsular war, but were published at long and irregular intervals. They gave much information with regard to the healthfulness of various stations, but the advent of the Crimean war caused their temporary discontinuance. In 1859 their publication was again resumed and they have since been issued annually. Army statistics have been collected in France and Germany since the Napoleonic wars, but have not been regularly made available for general use; frequently being issued only in part or not at all. Of late years, France has not given out full information as to the occurrence of disease and death among her military forces. Elaborate statistical reports with respect to the health of troops are now published by Austria, Russia, Belgium, Italy and other foreign countries. In the United States army, satisfactory data for the period prior to 1840 are not available, and it is only since 1884 that figures sufficiently elaborate to be of any great value to the statistician have been compiled and published. At present, the official returns show not only the amount of loss the army annually incurs from various forms of disease, but also the causes leading thereto; as influenced by race, age, length of service, arm of service, season, station and other factors.

Little information is gained by recording the statistics of disease as a whole; since so many factors combine in the production of the final result that these must be studied separately to arrive at a proper understanding of the significance of the latter.

The main points upon which army medical statistics are based are as follows:

1. The number of admissions to sick report as compared with the number of persons furnishing the sick. This is accomplished by taking the actual numbers in both classes and reducing them to a comparable standard in rates per thousand. The numbers furnishing the sick are obviously reduced by those sick in quarters or hospital; but as a general rule an equivalent number of men are returned to duty or are enlisted to replace the losses through death or disability. In our service, statistics are based on the total strength.

2. The rate of deaths per thousand strength. This is obtained by the division of the total number of deaths occurring during the year by the mean annual strength, including the absent as well as those serving with the colors. The figures thus obtained are then reduced to rates per thousand.

3. The rate of discharges for disability from disease, per thousand strength—obtained by dividing the losses from discharge by the mean strength and then reducing to the above standard of comparison.

4. The total losses from disease, per thousand strength; as determined by the sum of the rates for mortality and for discharge for disability from this cause.

5. The rate of constant sickness, or constant inefficiency. This is given by adding the numbers put down as remaining under treatment at the end of each day, week or month and dividing by the number of days, weeks or months in the period desired, again reducing to the comparable standard.

6. The number of days of service lost by each soldier. This is found by adding together the total number of sick days furnished by a command during a given period and dividing the result by the mean strength of the command for that period.

In all computations the figures are reduced to common terms of one year and one thousand strength.

Comparative Loss in Campaign from Sickness and Wounds.—Since the great military epidemics of antiquity—the destruction of the Assyrians under Sennacherib; the plague described as occurring during the Peloponnesian war; the pestilences which ravaged the Roman and Carthaginian armies; the great losses sustained by the army of Severus in the marshes of Caledonia—it has been established as a general rule that, in protracted wars, armies suffer much less from wounds and deaths incurred in action than from disease; a fact which conclusively shows the necessity for a proper knowledge of military hygiene. The constant advance in sanitation, however, based upon a more accurate knowledge of etiological factors, has exerted a marked effect in diminishing military morbidity and mortality; and while in the future comparatively high rates for sickness and death among troops engaged in war are always to be expected, it is scarcely possible that such disastrous epidemics as have prevailed in times gone by could be repeated in the future. Further, wars become shorter as they become, through modern refinements, more expensive; and troops, particularly in an aggressive and decisive campaign, are not now exposed to unhealthful influences to as great a degree as was the case when hostilities were more protracted. With improvement in the effectiveness of arms, both as regards range and rapidity of action, the proportion of casualty for any period of action must naturally be increased—and hence there is a constant tendency toward the approximation of the rates from wounds and disease.

From the records of the past, however, many valuable lessons can still be drawn. In 1809, during the Walcheren expedition, the mortality in the British army from disease was 346.9 per thousand effectives, while only 16.7 per thousand were killed by the enemy. A few years later the British army in Spain lost three times as many men by disease as by the result of conflict, and the sick rate mounted to such proportions that more than twice the number of men composing the army passed through the hospitals during the year. In the Russian campaign against Turkey, in 1828, it was estimated that 80,000 men died of disease and 20,000 in consequence of wounds. During General Scott's campaign in Mexico the

losses from disease alone exceeded 33 per cent. of the effective strength of the forces under his command; and of a single regiment of Indiana volunteers, which entered the service 1,000 strong, only 400 returned to the State for muster out. Laveran states that in the Crimean War the allies lost 52,000 men in six months, of which number 50,000 men were unharmed by the Russians; while during the entire war, according to Viry, the French lost, in round numbers, out of a total force of 300,900 men, no less than 95,000, of whom 75,000 died of disease and only 20,000 died on the field or succumbed to wounds. In this campaign nearly one-fourth of the French medical officers are said to have perished from disease. During the war in Italy, in 1859, a period of hostilities of only short duration, there were, from the French force of 200,000 men, 129,950 admissions to hospital. In the war carried on by France in Mexico the mortality from gunshot and that from sickness was in the proportion of 10 to 29.

The mortality among the United States forces in the Civil War was divided as follows:

Mortality.	White.	Colored.	Total.
Killed in battle	42,724	1,514	44,238
Died of wounds	47,914	1,817	49,731
Died of disease	157,004	29,212	186,216
Died, cause unknown	23,347	837	24,184
Total	270,989	33,380	304,369

From the most reliable data available, the deaths in the armies of the Confederate States during this struggle did not fall short of 200,000, three-fourths of which number were due to disease and one-fourth to the casualties of battle.

In 1866, in the war against Austria, out of a total strength of 437,260, the Prussians lost in an unusually brief and decisive campaign 6,427 men by sickness and 4,450 at the hands of the enemy. The Franco-German war, in 1870–71, furnishes the only exception to the general rule that more men are killed by disease than by the weapons of the enemy, since of the German army 33.7 per thousand strength fell in battle, while only 18.6 per thousand died of disease. This admirable result was largely due to the proper observance of sanitary precautions; assisted, no doubt, by the brevity of the campaign, the rapidity of the movements and the fact that active operations were conducted during the most healthful season of the year. In the Russo-Turkish war of 1878, according to Viry, the Russians lost 102,799 men, of whom only 16,578 were killed by the enemy. During the Spanish-American war of 1898, for the five months which included the total period of hostilities, of the 274,717 officers and men enrolled in the United States forces, there were only 345 men killed by the enemy while 2,565 succumbed to disease. For the whole year of 1898 the deaths from wounds in our service gave a rate of 0.62 per thousand strength, the killed in battle amounted to 2.79 per thousand strength, while the deaths from all causes aggregated 30.31 per thousand. Even in July, the month in which aggressive operations against Santiago were

conducted, the killed in action amounted to only 1.25 per thousand, while the deaths from disease were 1.78 per thousand.

An interesting side-light on the later results of hard campaigning is given by Rosse, in his statement that of the old soldiers carried on the United States pension rolls those disabled by disease are more than four times greater in number than those pensioned for wounds.

Death Rates in Civil and Military Life.—The difficulties attending an accurate comparison of death rates for the military service and those of civil life are necessarily very great. Owing to the rejection of intending recruits, many individuals are at once returned to private life whose early demise would otherwise have gone to swell the military death rate. Further, the army is maintained as a select body of physically sound men, and its weaklings are constantly undergoing elimination from the service ultimately to increase the mortality of civil life. Hence the civilian rates are unduly increased, while army statistics fail to show all the deaths presumably due to military service—and it is obvious that the more rigorously the standard for the soldier is maintained as regards physical excellence, the more favorable the showing apparently made for a military life. Vallin, in France, in 1871, placed the probable error due to the above causes at as much as 9.19 per thousand, thus practically doubling the figures for the military death rate of his time. Viry considered this allowance to be too high, but believed that a rate of 3.60 per thousand for such as leave the colors with incurable disease should be added to the military and subtracted from the civilian death rates; thus making a difference of 7.20 per thousand. The later estimates of Marvaud placed the probable error at 4 per thousand. While it is probably correct for the French service to add 3.60 or even 4 per thousand to the military death rate, to deduct the same number from the civilian rate involves the broad assumption that the numbers in each class exactly correspond. For our own service, the immense disproportion existing between the present small army of 65,000 men and the large number of males of the military age living in the United States renders the influence of the comparatively small number of soldiers who may be discharged for incurable disease, upon the civilian death rate, of so little importance that it may practically be disregarded. The census returns for 1880 give the annual death rate for disease as 6.97 per thousand for all males between the ages of twenty and forty-five years. During the same year the mortality from disease in the United States army was 5.88 per thousand—apparently a distinct advantage in favor of the military service. If, however, Viry's factor, above mentioned, be accepted as correct for our service, the true mortality dependent on military service becomes 9.48, or 2.51 per thousand in excess of the civilian rate for the same period. As it is probable that since that time the death rate in the military service has diminished in proportionately greater degree than has been the case in civil life, it may be fairly assumed that, under conditions of peace, the death rate in our army is at present but slightly in excess of the mortality for the same class in civil life. The results obtained by Farr in his comparison of the death rate in the British army with the corresponding classes of civil life, made a generation ago, are as follows:

Age.—20–25—Soldiers	17.0	death rate per 1,000.
Civilians	8.4	" "

Age.—25–30—Soldiers	18.3	death rate	per 1,300.
Civilians	9.2	"	"
30–35—Soldiers	18.4	"	"
Civilians	10.2	"	"
35–40—Soldiers	19.2	"	"
Civilians	11.6	"	"

According to Notter and Firth, the present death rate of the civil male population in England, at the soldier's age, is as follows:

Age.—20–25	5.4	mortality	per 1,000.
25–35	7.4	"	"
35–45	12.8	"	"

Between the ages of 20 and 34, according to these authorities, the mortality is in favor of the soldier, but after 35 the mortality is reversed and the civil rates are lower.

For the British service the death rate for the home stations was 3.42 per thousand in 1897 and 4.68 per thousand for the decade 1887–1896. If the civilian death rate for all males of the military age be accepted as about 7 per thousand, the showing made compares favorably with similar figures for the German army and is superior to the French mortality rates. This is certainly a great improvement over the conditions existing in 1856, when it was shown that the mortality in the army at large was twice as great as among the civilian population, and in the case of the Foot Guards three times as great.

As regards the German army, it was recently stated by its surgeon-general that during the early part of this century the death rate of the male civil population of Prussia, between 20 and 30 years of age, was lower than that of the military death rate, the figures being 14 per thousand for the army and 10 per thousand for the civil population. This condition is now reversed, and in 1893 the death rate in Prussia for the civil male population from 20 to 30 years of age was 6.38 per thousand, while at the same time the mortality for the German army was 3.00 per thousand. While these results are certainly admirable and are undoubtedly in large part due to careful observance of sanitary regulations, it should be remembered that soldiers unable to maintain the required physical standard are probably more thoroughly eliminated in the German service, and at an earlier period in their military training, than in other armies.

In the French army, on the home stations, the average annual death rate from 1882 to 1890, inclusive, was 7.88 per thousand strength; while Bertillon fixed the annual mortality among the civilian male population, between the ages of 20 and 25, at 10.60 per thousand. Marvaud, however, believed that the estimate made by Bertillon was too low, and placed the annual death rate for civilians of the military age at 12 per thousand. Using Marvaud's coefficient of error, given above, the corrected rate for the French military service would become 11.88, while it would be 8 per thousand for the same class in civil life. Marvaud concludes, with reference to this subject, "that, in spite of all ameliorations which have been introduced, chiefly of late years, into the hygienic surroundings of the French soldier, his mortality rate is still elevated and certainly exceeds that of the same sex and age in civil life."

Loss of Time from Sickness.—In the United States service the annual average number of days lost per man, for the decade 1886–1895, was 14.64. For the year 1896 it was 12.43 and in 1897 it was 13.08. In comparing the number of days lost by white soldiers with those lost by colored troops, the showing is slightly in favor of the latter. For the entire British army, during the decade 1887–1896, the number of days lost per man was 21.38, while during 1897 it was 22.72. Among the British troops at the home stations the number of sick days per man did not differ very greatly from those of our own army for the same periods, being only a fraction of one day in excess. According to Rosse, in a statement of the morbidity of various armies issued about 1884, the lowest rates given were those of the Portuguese, Austro-Hungarian, Italian and German armies, the sick days of each man in the effective force being from 13 to 15 yearly among the troops of these nations, while in the French and English armies, prior to that date, the rate had been 16 to 17 annually.

As compared with the time lost by the corresponding classes in civil life, Rosse noted that, for the period 1872 to 1892, the average annual number of days of sickness was 6 to 8 for each workingman belonging to various mutual aid societies; he fixing the general military morbidity for the same period at figures two and one-half times greater than those of the corresponding civil classes. According to Paget, the following rate of sickness, such as incapacitates for work, may be expected at different ages for males of the English working classes: At 20 years expect 4 days of sickness yearly; at 20–30 years expect 5 to 6 days of sickness yearly; at 45 years expect 7 days of sickness yearly. Marvaud states that, in 1894, the French soldier lost 13 days annually—9 in hospital and 4 in barracks—while his civilian compatriots of corresponding age lost on an average only about half that time; notwithstanding the fact that the hygienic surroundings in the military service were much superior to those of civil life.

While in time of war or active operations the existence of a high rate of inefficiency and the loss of a greater amount of time are to be anticipated, such conditions, as compared with those of the corresponding classes of the male civil population, should not, theoretically, obtain in time of peace. Their actual existence under the latter condition is probably due to the fact that the workingman does not feel able to stop his daily task except for serious illness, while the soldier—whose pay and living are assured and whose medical attendance is gratuitous—is inclined to abuse his privileges, often endeavoring to get his name on sick report for the slightest indisposition, or none at all, and to have it retained there for as long a period as possible; this being particularly attempted when any unusually irksome or disagreeable task is to be performed. That such, indeed, is the case is demonstrated by the fact that, according to Billings, it may be estimated that for every case of death there is an average of two years sickness in the civil community; while in the United States army, for the absolute number of deaths occurring and days of service lost during the year 1897, the proportion was such as to show a total of 3,867 days of sickness to each death reported. This gives a total of 10.6 years sickness for each death; a rate more than five times greater than that obtaining in civil life and one which can be explained only by the above

hypothesis. In view of the unfavorable showing made by military statistics in this respect, it would appear that greater discretion and severity should be exercised in admitting the soldier to sick report; and that, if once admitted, his earlier return to his duties would frequently be productive of neither injury nor hardship.

Race as Influencing Military Mortality and Morbidity.—While satisfactory data on this subject as regards foreign armies are naturally not available, the several rates from disease in our own service, with its heterogeneous personnel, have been calculated according to nativity. For the seven years 1890–1896, they were determined, per thousand strength, to be as follows:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
United States	1,043.43	30.74	12.98	3.96	16.94
Ireland	962.05	26.87	14.52	5.46	19.98
Germany	810.10	24.67	13.20	4.14	17.34
England	907.11	23.56	12.46	4.26	16.72
Canada	1,033.14	32.81	18.87	4.16	23.03
Scandinavia	886.08	26.55	13.33	5.17	18.50
Scotland	852.38	25.64	12.50	1.47	13.97
Switzerland	893.75	27.82	12.31	2.90	15.11
Austria	807.14	21.63	16.53	2.67	19.20
Denmark	836.93	26.21	13.33	5.55	18.88
France	1,049.43	30.89	10.56	7.04	17.60
All others	821.42	23.90	13.66	3.86	17.52

It should be noted, however, that the figures given for the countries named in the latter half of the above table are not to be regarded as absolute, since they are not based upon a sufficiently large number of men to avoid the possibility of error. These rates are, however, of particular interest since, so far as they go, they tend to bear out the popular belief that the native-born American possesses a greater proportion of vital force and greater power of resistance against death than does the foreigner.

Race proclivity, as regards sickness, is well shown by the records of the British forces in the West Indies, in which, for the ten years 1879–1888, the admissions per thousand of strength for white troops were 966.9, colored, 1,114.2; constantly non-effective, whites 46.62, colored 62.35; deaths, whites 14.94, colored 14.81; discharges for disability, whites 13.57, colored 39.33. In the United States service, the much greater proportion of sickness and deaths occurring among the negro troops during the Civil War, as compared with white soldiers, is shown in the chart on page 619. For the decade 1877–1886, the death rate among the whites of our army was still much lower than among the colored troops; the rates being 9.97 per thousand for the former and 12.91 for the latter. In 1888 the report of the surgeon-general called attention to the fact that the amount of sickness among the colored troops was greater than that among the white soldiers stationed in the same military departments. There has been, however, a constant tendency for the past twenty years toward the approximation of the rates for the whites and blacks in our service; and the relative rates per thousand for white troops as compared with those for the colored troops, during the year 1897, were as follows:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
Whites	35.72	11.04	9.62	5.05	14.67
Colored	37.24	10.89	9.51	5.89	15.40

Since 1897 the relative proportion of deaths, discharges and admissions to hospital has not differed to any extent among the white and colored troops.

In the distribution of diseases among white troops, according to nativity, typhoid fever and rheumatic fever had their greatest prevalence in our service, for the years 1890–1896, among the Canadians and Scandinavians. The highest admission rates for consumption were 5.70 among the French and 4.76 among the Scotch; the lowest rates were 1.42 among the English and 1.49 among the Germans—the rate among the natives of the United States being 3.33. Pneumonia was more frequent among Canadians, 5.18, and Scotch, 4.76, than in men of other nativities. The rate for this disease among the natives of the United States was 3.90. Venereal disease prevailed more among men born in the United States and Canada than among the others, the admission rates for these two classes being 93.98 and 91.92 respectively; the Irish and Swiss had the lowest rates, 47.66 and 50.96. The Irish, however, had by far the largest relative number of cases of alcoholism, 90.96. The smallest rates for this cause were given by the Danes, 12.59, and Austrians, 19.00; the admission rate for the native-born American soldier having been 28.51 for this cause.

Sickness and Death Rate as Affected by Season.—Military morbidity and mortality are to a certain extent influenced by seasonal changes; varying according to the climatic conditions prevailing in each country or locality, by which the propagation of certain affections is either favored or retarded. In the French army the admissions to hospital for disease, in time of peace, reach the maximum of 57 or 58 in January and fall to the minimum of about 38 per thousand in September. In the Italian army, for the period 1872–1892, the greatest amount of sickness occurred in March and the least in November. In the United States service the late summer period is the most unhealthful, while the late fall and early winter give the least sickness as far as troops on the home stations are concerned.

On analyzing the figures for the seasonal prevalence of disease as it existed during the decade 1888–1897, the monthly admission rate was usually high in January from influenza and bronchitic attacks. From this point it fell to a minimum in April, after which it rose, slowly during May and June and rapidly in July and August, to the maximum of the year. It remained high in September, but fell again during the last three months of the annual period. The wave of prevalence during the months of July, August and September was due to malarial diseases. Prior to the decade mentioned this autumnal wave was larger than in recent years, and there was frequently a slight prominence in the curve in May or June, corresponding with a sudden increase of cases of intermittent fever.

For the year 1899 there is little to be learned from a study of this curve of prevalence, for the climatic and other influences which affected it

were too complex to be considered from this point of view; and even with troops on the home stations, differences are found which are evidently not

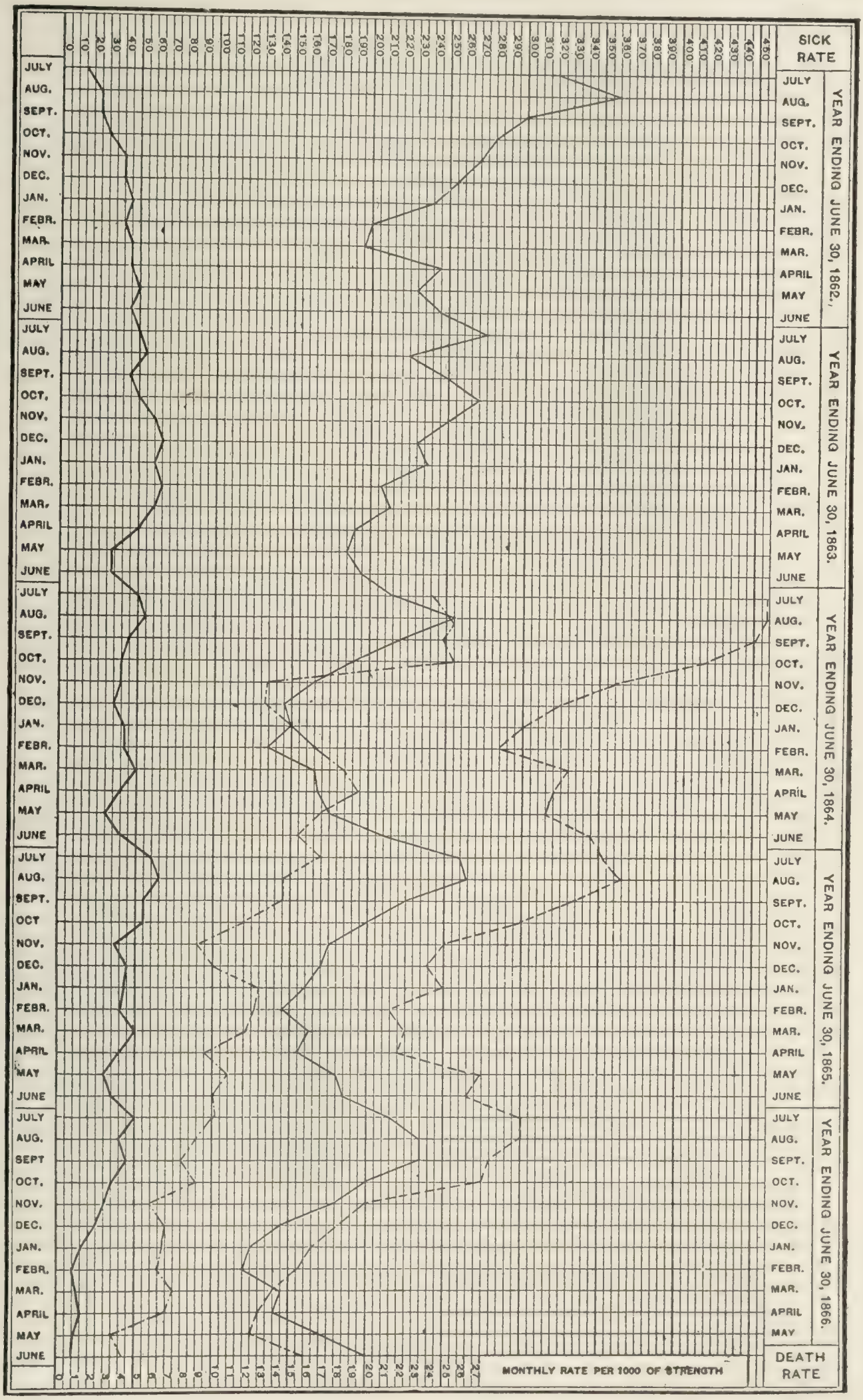


FIG. 319.—Diagram Showing the Sickness and Deaths among the White and Colored Troops of the United States Armies during the Civil War and the Year Following that War, Expressed in Rates per Thousand Strength.

Mortality, White Troops ——————
Mortality, Colored Troops — — — — — —
Sickness, White Troops ——————
Sickness, Colored Troops — — — — — —

(From the "Medical and Surgical History of the War of the Rebellion.")

due to climatic conditions in this country but to previous service of the troops in other climates. The conditions of field service also materially alter the rates of seasonal prevalence as established for troops in garrison.

Thus for the year 1898, when the army, if not entirely engaged in active military operations, was, after the month of March, still in the field and on a war footing, the monthly rates per thousand strength were as follows:

	Admissions from disease.	Discharges from disease.	Deaths from disease.	Total losses from disease.
January	68.11	0.40	0.33	0.73
February	59.68	.40	.18	.58
March	65.75	.50	.21	.71
April	65.12	.95	.24	1.19
May	80.90	.31	.21	.52
June	68.25	.29	.36	.65
July	150.15	.31	1.81	2.12
August	254.61	.41	6.14	6.55
September	271.79	.30	4.73	5.08
October	200.48	.79	2.06	2.85
November	186.06	1.11	1.07	2.18
December	212.63	1.14	.84	1.98

Locality as Affecting Health.—This is clearly a subject which can be only generally considered, since the rates for each station will vary with the local conditions of climate, soil, water, environment, the character of the service upon which troops are employed and many other factors. Within the United States, for troops in the various military departments existing under conditions of peace, the following table shows the relative amount of sickness during the year 1897.

Department.	Annual death rate per 1,000 strength.	Annual discharge rate per 1,000 strength.	Duration of treatment among patients who died.	Duration of treatment among patients who were discharged for disability.	Average number of sick daily.	Average duration of treatment.	Total losses by death and discharge for disability.	Admission rate per 1,000 strength.	Constantly non-effective per 1,000 strength.
East	5.61	5.85	17.80	83.40	287.28	10.38	11.46	1,260.04	35.83
Missouri	5.30	6.91	16.78	86.06	157.36	11.13	12.21	1,188.89	36.25
Dakota	4.77	9.55	28.17	109.54	85.28	12.70	14.32	975.33	33.93
Platte	7.27	4.59	22.37	119.67	96.61	10.43	11.86	1,294.41	36.99
Texas	6.24	7.38	5.27	100.38	69.88	9.51	13.62	1,522.14	39.65
Colorado	3.56	13.93	73.45	115.81	110.07	10.21	17.49	1,274.05	35.66
California	3.15	6.30	24.40	66.40	41.81	11.81	9.45	813.60	26.33
Columbia	6.20	10.33	36.56	75.47	37.25	11.94	16.53	788.44	25.65

From the above it is seen that the Department of California is the most healthful, with the Department of the Columbia and Dakota closely following. The Department of Texas has long been recognized as the most unhealthful military division within the limits of the United States.

The statistics for the entire British army in time of peace are of particular importance, covering as they do a large number of geographical divisions under diverse climatic conditions and enabling the making of accurate comparisons through the similar sanitary, military and administrative conditions prevailing throughout the whole. The figures for that service, for the ten years 1887 to 1896, are given below.

RATIO PER 1,000 STRENGTH.

European Troops.	Admitted.	Died.	Sent home as invalids.	Discharged as invalids.	Constantly non-effective from sickness.	Average sick time to each soldier.	Average duration of each case of sickness.
						Days.	Days.
Troops at home and abroad	997.4	8.81	23.65	14.52	58.57	21.38	21.47
United Kingdom	735.9	4.68	....	16.27	42.51	15.52	21.04
Gibraltar	708.8	4.01	15.23	8.25	46.65	17.02	24.01
Malta	666.9	7.53	19.20	10.53	44.29	16.17	24.25
Egypt and Cyprus	998.8	11.08	19.04	12.09	65.48	23.90	23.93
Canada	499.1	4.37	14.34	11.90	25.54	9.32	18.68
Bermuda	559.2	10.07	12.65	8.14	29.58	10.80	19.31
West Indies	1,119.3	8.43	20.23	13.40	64.48	23.54	21.08
West Africa*	2,652.7	45.02	237.94	12.86	84.89	30.98	11.68
South Africa and St. Helena	868.3	6.63	23.97	14.54	55.85	20.39	23.48
Mauritius	1,364.4	15.04	55.94	17.42	73.76	26.92	19.37
Ceylon	1,028.0	11.10	20.35	11.42	58.29	21.27	20.69
China	1,324.7	11.31	33.34	14.28	64.97	23.71	17.91
Straits Settlements	1,072.1	6.73	18.14	9.27	72.48	26.46	24.68
India	1,443.9	15.50	25.17	13.24	84.87	30.98	21.45
On board ship	1,132.8	6.41					

* For eight years only, 1889 to 1896.

It is readily seen that the total losses vary from the minimum of 12.26 per thousand at Gibraltar to the maximum of 57.88 on the west coast of Africa; while the death rate of troops at home is only about half that of the entire army. The discharges for disability in the latter instance are slightly higher, while the constant non-effective is considerably lower, as is also the number of days lost by each soldier.

The mortality among the European troops of the French army on foreign service, per thousand strength, according to Gayet, is thus proportioned among the following stations:

Algeria	11 to 12
Antilles	18 to 22
Senegal	about 73
Réunion before the Madagascar expedition	28 to 30
Réunion after the Madagascar expedition	80 to 90
New Caledonia	9 to 10
Cochin China	22 to 24
Tonkin	about 75

While thoroughly satisfactory statistics with regard to our own troops at tropical stations are not as yet available, owing to the somewhat unsettled conditions as yet existing, particularly in the Philippines, figures for the regular and volunteer forces for the year 1899 are as follows:

Per 1,000 of Mean Strength.	Cuba.	Porto Rico.	Pacific Islands.
Admissions for disease	2,537.98	2,255.97	2,206.36
Discharges for disease	16.26	16.63	13.16
Deaths from disease	16.36	9.12	15.30

Similar statistics for troops stationed in the United States during the same period, per thousand strength, were: Admissions for disease, 1,496.84;

discharges for disease, 22.28; deaths from disease, 6.56. It is thus evident that service in the tropical islands is about three and one-half times as hazardous as service at home stations.

Branch of Service as Affecting Health.—It has long been noted that troops of certain arms are more prone to disease and death than are others; this being explainable by the character of the duties each is required to perform, as well as by the diverse conditions of environment under which they are, through military necessity, forced to exist. As compared with infantry and artillery, the cavalry service may be considered to be somewhat more unhealthful and dangerous to life; this being due to the more arduous nature of the service and to the uncleanly nature of a large part of the duties of the mounted soldier. The chief factor in raising the rates of the cavalry above the mean for the army is, however, due to the much greater liability to accident. In time of peace, for all armies, the mortality and sickness in the infantry is usually less than in any other of the main branches of the service, but in war this favorable showing does not continue.

In the United States army, for the seven years 1890–1896, the rates for disease alone, per thousand enlisted men, divided according to branch of service, were:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
Infantry	916.27	27.96	13.67	4.34	18.01
Cavalry	1,076.56	30.87	13.36	3.98	17.34
Artillery	1,163.61	31.81	15.61	2.94	18.55
Ordnance	1,007.15	25.69	9.79	7.20	16.99
Engineers	1,371.55	29.88	7.56	2.84	10.40
Medical department	468.85	14.99	11.24	5.14	16.38
All others	941.51	30.23	10.15	5.07	15.22

The high death rate noted in the enlisted strength of the Ordnance Department is probably largely dependent on the greater age of these men; many being old soldiers, superannuated, unfit to stand hard service and broken in constitution by the hardships of a former active life.

For the seven year period above noted the rates for all causes were:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
Infantry	1,154.21	35.36	16.72	6.49	23.21
Cavalry	1,464.10	43.92	17.61	7.25	24.86
Artillery	1,457.87	41.11	18.47	5.30	23.77
Ordnance	1,187.38	31.81	11.23	10.65	21.88
Engineers	1,684.92	38.45	7.88	4.73	12.61
Medical department	527.04	17.08	12.19	6.09	18.28
All others	1,100.02	34.77	12.12	6.13	18.25

The high rate of admissions among the engineer troops was due to injuries and malarial fevers, with a considerable excess of alcoholism, bronchitis, diarrhœa and rheumatism. The disabling causes which produced the high rate in the cavalry as compared with infantry were injuries, which gave a rate of 387.54 as compared with the infantry rate, 237.94; but the excess of admissions among the cavalry was not thus entirely ac-

counted for. Malarial affections were the principal causes of this excess, but diarrhœa, boils and abscesses, and conjunctivitis also aided in making up the total.

Among the officers, for the above period, the sick rate was largest in the artillery, 980.11 per thousand. Non-efficiency was greatest among officers of the cavalry and artillery—53.90 and 52.57 respectively. Medical officers had a higher rate (47.07) than infantry officers (46.05). The death rate per thousand among officers, according to branch of service, was as follows:

Infantry	8.81	Engineers	11.07
Cavalry	10.34	Medical department	10.20
Artillery	6.08	All others	12.32
Ordnance	17.41		

Death from injury was relatively more frequent among ordnance officers than in those of other corps.

Marvaud gives the following figures as showing the comparative mortality in different branches of the French service for the six years 1880–1885, inclusive.

	Death rate.	Loss by invaliding.	Total losses.
Engineers	5.2	14.4	19.6
Light infantry	7.0	11.7	18.7
Artillery	7.4	12.9	20.3
Cavalry	8.8	13.2	22.0
Infantry of the line	10.2	16.6	26.8
African light infantry	17.2	14.5	31.7
Foreign legion	19.8	8.7	28.5

In the English service, in 1897, the following rates per thousand obtained for troops on the home stations.

	Deaths.	Constantly non-effective.
Infantry	2.78	44.79
Royal engineers	3.64	17.75
Cavalry	3.98	42.39
Royal artillery	4.00	32.49
Foot guards	4.20	63.03

In time of war it is, of course, the troops which are most exposed to the dangers of battle and the hardships of campaign which suffer to the greatest extent in respect to sickness and death.

Influence of Length of Service upon Morbidity and Mortality.—The most extensive figures for the United States army upon this subject, compiled to include a period of seven years, merely divide the men into those who have had less and those who have had more than one year of service—and these show that recruits during their first year with the colors are especially liable to sickness. For the entire period (1890–1896), the admission rate to hospital of this first class was 2,122.17, while that of the older soldiers was only 1,093.07—or about one-half as much. The non-efficiency for recruits was 61.76, as compared with 32.99 for men of longer service; and their sickness was of such a character as to cause

24.96 per thousand of their number to be discharged on certificates of disability, as compared with a discharge rate of 14.76 among the others.

As to the causes affecting the above figures, the vaccination practised in the case of recruits brought a considerable number of cases on sick report; a little over 200 per thousand strength being thus added to their admission rate. With the exception of alcoholism, these young soldiers appear to have been more susceptible to all disabling causes than their more experienced comrades. As illustrative of this may be cited their admission rate for injuries, 414.91, as compared with 242.93 among the others; for venereal diseases, 156.52, as compared with 65.81; malarial diseases, 137.84, as compared with 70.97, and typhoid fever, 11.22, as compared with 4.68.

For the single year 1885, the admissions to hospital in the United States army, according to length of service, were divided as follows:

Period.	Absolute number in each class.	Rate of admissions per 1,000 strength.
First year and under	6,205	2,254
Second year	3,632	1,064
Third year	2,645	984
Fourth year	2,249	967
Fifth year	1,053	1,064
Sixth year	1,148	901
Seventh year	897	970
Eighth year	629	1,057
Ninth year	738	927
Tenth year	921	991
Twelfth year	1,351	1,007
Fifteenth year and over	4,587	823

For the same year the discharges for disability, divided according to length of service, were as follows:

Service.	Discharges for disability, per 1,000 strength.	Service.	Discharges for disability, per 1,000 strength.
Under 1 year	64.9	7 years	15.3
1 year	41.5	8 "	16.1
2 years	33.3	9 "	12.2
3 "	29.0	10 "	19.6
4 "	16.8	12 "	23.1
5 "	22.2	15 " and over	22.1
6 "	23.2		

For the same year the death rate per thousand strength, according to length of service, was determined to be:

Less than one year of service	10.90
One year of service	4.80
First five years of service	4.54
Second five years of service	5.22

While the absolute number of men in the army of the United States during the year 1885 can scarcely be regarded as sufficiently large to warrant any exact deductions, it is certainly safe to assume that the processes of elimination in our army are most active by far during the first twelve months of service; after which the total losses fall below the general rate for the whole army, not to rise again until the more mature men of ten years' or longer service succumb to infirmity.

Viry states that in the French service the annual losses by death and discharge for disability amount approximately to 40 per thousand during the first year of service, 30 per thousand during the second year with the colors and 20 during each of the subsequent years. According to Ordronaux, statistics for the French army some years ago showed the following to be the average annual mortality:

Service.	Loss per 1,000.	Service.	Loss per 1,000.
1 year	7.5	5 years	3.0
2 years	6.5	6 "	2.0
3 "	5.2	7 "	2.0
4 "	4.3		

In comparing the amount of sickness among French soldiers of one year of service with those of two or three, Viry found that in 1888 there were, per thousand of each class, 866 admissions among the former and 432 among the latter; in 1889 the numbers were 859 and 483, and in 1890 they were 826 and 559 respectively.

The proportionate mortality in the German army for the year 1889–90, in respect to length of service, out of each 1,000 deaths, was as follows:

Less than one year of service	432.0
From one to two years' service	248.0
From two to three years' service	143.8
From three to four years' service	29.5
Four years' service and upward	146.7
Total	1,000.0

In the discharges for disability in the German army for the same year, out of 8,740 men so discharged 78.3 per cent. owed their incapacity for service to causes existing prior to enlistment. Hence it is not surprising that the majority of men so discharged should have been less than one year with the colors. The percentage of discharges according to length of service was as follows:

First year	84.4
Second year	8.6
Third year	5.0
Fourth year	2.0

Under conditions of tropical service the raw and unseasoned recruits are proportionately even more prone to disease than is the case in temperate climates, as is well shown in the following rates for the British troops in India during the year 1897.

Length of service in India.	Average strength.	Admissions.	Deaths.	Invaliding.	Ratios per 1,000 Strength.		
					Admissions.	Deaths.	Invaliding.
Under 1 year	11,680	21,700	344	302	1857.9	29.45	25.86
1 to 2 years	11,580	18,795	217	423	1623.1	18.74	36.53
2 " 3 "	11,368	17,929	208	475	1577.1	18.30	41.78
3 " 4 "	10,099	14,866	124	446	1472.0	12.28	44.16
4 " 5 "	8,013	10,548	131	265	1316.4	16.35	33.07
5 " 10 "	8,874	11,728	151	288	1321.6	17.02	32.45
10 years and upward	1,806	1,222	31	59	676.6	17.17	32.67
Not stated	1,111	36	8	....	32.4	7.20	
Total	64,531	96,824	1,214	2,258	1500.4	18.81	34.99

Age as Influencing Sickness and Mortality.—In the United States service, for the seven years 1890–1896 inclusive, the relation between disease and age among the enlisted strength existed as follows:

Age.	Admissions to hospital from disease per 1,000 strength.	Constantly non-effective from disease per 1,000 strength.	Discharged for disability from disease, per 1,000 strength.	Deaths from disease per 1,000 strength.	Total losses from disease per 1,000 strength.
19 years and less...	2,244.79	60.73	22.61	5.32	27.95
20 to 24 years.....	1,359.63	39.52	14.42	2.93	17.35
25 " 29 "	896.65	26.06	11.96	3.13	15.09
30 " 34 "	755.64	21.53	10.69	3.73	14.42
35 " 39 "	718.43	21.32	10.32	4.32	14.64
40 " 44 "	798.09	24.87	16.65	7.46	24.11
45 " 49 "	755.01	24.16	15.26	10.97	26.23
50 " 54 "	843.48	28.96	31.11	13.18	44.29
55 " 59 "	875.22	34.93	43.55	16.75	60.30
60 years and over..	1,265.31	72.91	122.64	66.04	188.68

To better emphasize the great wastage of lives and the loss of military efficiency which has resulted from our mistaken policy of enlisting immature recruits, the above figures are presented also in diagrammatic form; no more forcible argument than which for the exclusion of the young and undeveloped from the military service could well be advanced.

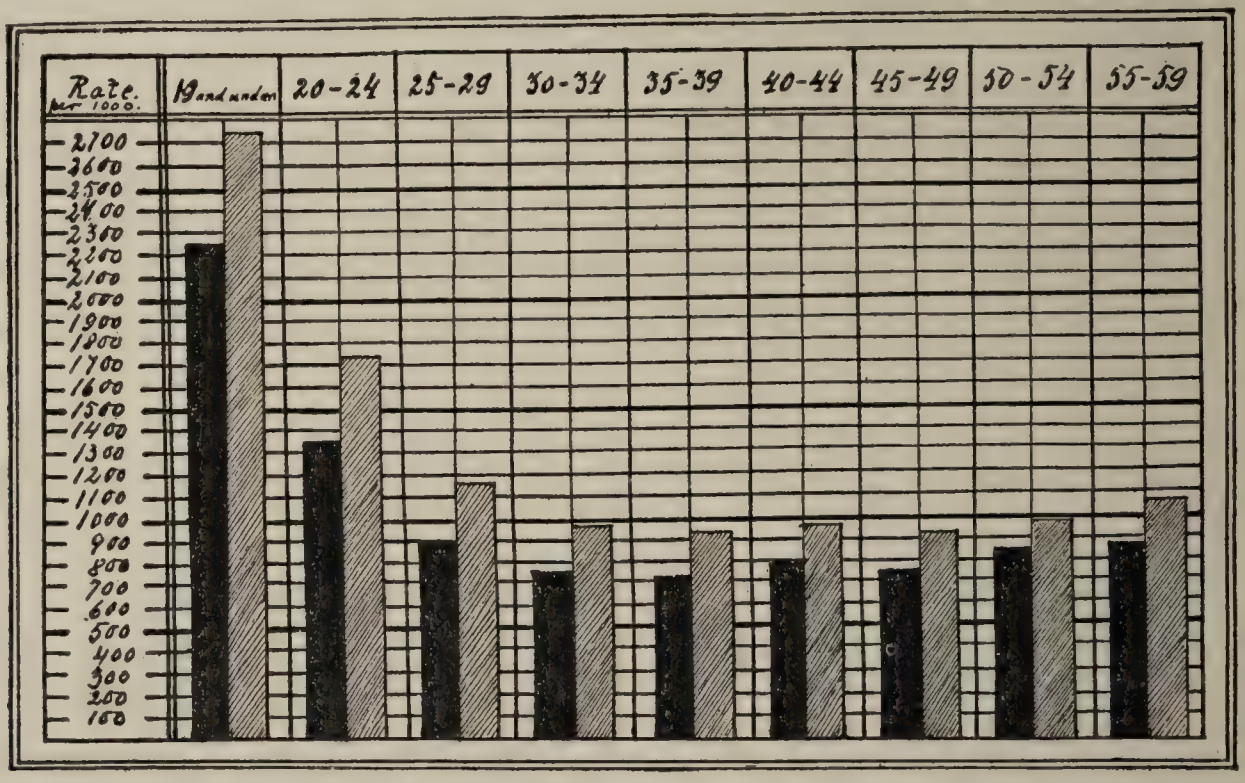


FIG. 320.—Diagram Showing the Influence of Age Upon Admissions to Sick Report in the United States Army, per 1000 of each Class, for the Seven Years 1890–1896.

The younger men, both officers and soldiers, appear particularly susceptible to disease as well as more prone to injury. For 1890–1896 noted above, typhoid fever was observed to be much more prevalent among those under 30 years of age. The rate for this disease in men from 20 to 24 years of age was 10.31; from 25 to 29 years, 5.74; from 30 to 34 years, 2.58. Enlisted men under 25 years of age suffered more from malarial fevers than did officers of the same age; but with the advance of years the rates of the men came to differ but little from those of their superiors. The

higher rates for venereal disease were given by men under 30 and particularly by those under 25 years of age; but, on the other hand, the rates for alcoholism increased with age. Tuberculosis appeared to be equally distributed among men between the ages of 20 and 50 years, but the excess of diarrhœal troubles was confined to soldiers under 25 years. Rheumatic fever was not specially prevalent among young men, susceptibility being increased after the age of 40 or 50 years. The rates for pneumonia were considerably larger after 45 years of age—as were also those for kidney disease.

In the French army, for the decade 1875–1884, the average annual death rate for all causes, per 1,000 strength, as given by Marvaud, was:

Under 20 years of age	6.72
From 20 to 22 years of age	10.92
" 22 " 23 " "	9.38
" 23 " 26 " "	8.59
" 26 " 30 " "	7.14
" 30 " 35 " "	8.51

The class less than 20 years old is not only a very small one, amounting, according to Bertillon, to only about three per cent. of the whole, but the young men composing it are all volunteers and before enrolment are subjected to an exceptionally severe physical examination, so that only the best lives are accepted. Hence, for the French army at large, the first year of service may be considered to begin at the age of 20–22 years. In commenting on the excessive mortality of the younger soldiers, Marvaud says: "It is during the first year of service that the number of deaths attains its maximum, a fact which proves the dangers provoked by acclimation to a military life."

The influence of age upon sickness, in time of war, is even more marked than during peace. According to Gayet, in the campaign of Benin the total losses by deaths and disease and from repatriation, among the French forces, were as follows:

Foreign legion	9.7 per cent.
Artillery of the marine	23.3 "
Engineers	24.2 "
Infantry of the marine	39.0 "
African battalion	47.9 "

In the two last classes the men were young and ill developed, ranging from 19 to 22 years of age; in the foreign legion the men were older, being between the ages of 25 and 35 years.

Influence of Military Rank as Affecting Health.—The report of the surgeon-general for 1897 gives statistics for our army to include the seven years 1890–1896; this being equivalent to a total strength for one year of 14,859 officers and 174,988 enlisted men. These figures show a sick rate of 765.69 per thousand for the officers and 1,258.90 for the men; but the inefficiency rate of the former class was much greater than that of the latter, being 44.27 per thousand as compared with 37.63 per thousand in the case of the enlisted force. The average death rate for officers was 9.56 per thousand, while among the enlisted men the annual mortality was only 6.52 per thousand. Such an unfavorable showing made by the officers as regards the rates for death and inefficiency is largely to be explained by the fact that the military life of the enlisted soldier practically ceases at

the age of 44 years, only 6.50 per cent. of this class remaining in service after that age; while of the officers included in the tabulation referred to, 37.25 per cent. were over 44 years of age. The latter class, then, while sharing largely with the enlisted men in the hygienic disadvantages of immaturity, had, in addition, the diseases of beginning old age and the results of long years of hard service to increase its death rate. It is to be noted that during this same period young officers under 25 years had only 784.20 admissions per thousand for disease, where the soldiers of the same age had an admission rate of 1,359.63; while the non-efficiency rate of the former was 29.61, as compared with the rate of 39.52 for the latter. This would indicate that if the same attention was given to sanitary details by the young soldier as by the young officer, the rate of constant sickness of the former would be correspondingly reduced.

The influence of petty rank and length of service with respect to sickness in the French army is shown in the subjoined table, constructed from data given by Marvaud covering the year 1888:

	Admissions per 1,000 Strength.	
	Detention rooms.	Hospitals.
Non-commissioned officers	111	248
Men having more than one year of service	260	172
Men having less than one year of service	567	299

The proportionately large number of non-commissioned officers treated in hospital is explained by Marvaud as being due to lack of suitable accommodations in the detention rooms for this class.

As illustrating the greater liability of officers to death in modern battles, as compared with the mortality among the enlisted men, the official reports of the British army in the Anglo-Boer war, up to the time of the occupation of Pretoria, showed that for every officer who died of disease thirty-four soldiers died from the same cause, while for every officer who was killed in action or died from wounds, but nine men so lost their lives.

Health of Troops during Peace.—The individual significance of the several factors which, taken together, determine the sanitary condition of our army in time of peace will be readily appreciated by reference to the table on pages 630 and 631. Diarrhœal affections have the highest admission rate for sickness, but the mortality from this cause is not great. Malarial diseases rank second in frequency, but, as shown by statistics, they are not of severe type and are readily amenable to treatment. Venereal diseases occupy third place in importance as regards admissions, but the constant non-efficiency through their influence is much greater than that from any other cause. Rheumatism and myalgia together furnish a large proportion of admissions and discharges, as does also bronchitis. The admissions for alcoholism are slightly above the general mean, but the rates for death and non-efficiency from this cause are small. All the rates for typhoid fever are low. As to injuries, the several figures for contusions and sprains are all large—those for wounds, excluding gunshot injuries, being considerably lower than those for contusions but still somewhat in excess of the general average.

With regard to sickness, deaths and non-efficiency in the British service for the home stations (see pages 632 and 633), the fact which at once attracts attention is the high ratio given by venereal affections; the admissions from this cause being more than half again as high as from any other affection or group of diseases. For gonorrhœa, primary and tertiary syphilis, the individual rates for non-efficiency are much higher than for such diseases as are summarized as affections of the respiratory and digestive systems. The rates for rheumatism and influenza are high, while diseases of the skin and of the connective tissue are common. Alcoholism is a minor factor in increasing the rates for sickness, deaths and non-efficiency.

Decrease in Rates Under Conditions of Peace.—That improvement in the sanitary administration and state of armies is constantly being made will be unhesitatingly admitted; yet but few are aware of the stupendous progress in this respect which, particularly during the past generation, has been accomplished by military hygiene. Not only is this the case in our own service, but in foreign armies also, and, on reviewing the sanitary conditions which for their time were considered to be excellent, it is apparent that still further decrease in the several rates may justly be anticipated for the future. For the United States army the following charts (see pages 635 and 636) so well illustrate the remarkable decrease in sickness and death which has occurred during the past three-score years that any extended discussion of the matter would seem to be superfluous. Suffice it to say that, in our service, the death rate for the five years preceding the Spanish-American war was about three and one-half times less than that for the five years preceding the war with Mexico, while the rate for sickness underwent a diminution of about two and one-third times during the period included by these dates. Since the year 1872 the death rate from all causes has dwindled to about forty per cent. of what it was at that time, while the death rate from sickness alone has fallen almost as much; and during the same period the rate for admissions to sick report has diminished more than one-half.

In the German army, according to official figures recently submitted to the Reichstag, the number of admissions to hospital from disease, per thousand strength, underwent a decrease from 1,496 in the year 1868 to 867 in 1894. In 1868 the annual death rate per thousand was 6.9, 4.82 in 1879, 3.24 in 1888, and only 2.60 in 1896—a magnificent result, in the attainment of which the due observance of sanitary detail, together with the careful selection of recruits, were main factors. Military epidemics, in this showing of the German army, have above all lost ground. Smallpox is rare, and caused only two deaths during the twenty years 1873–93. Dysentery was reduced from 6.8 per thousand strength in 1874 to 0.39 in 1894. Typhoid fever gave a rate of sickness of 33.8 per thousand strength in 1868 and 2.4 per thousand in 1894. The typhoid death rate was 2.2 per thousand in 1868 and 0.81 per thousand in 1894. Malaria showed a rate of sickness of 27.6 in 1868 and 0.81 per thousand in 1894; while contagious eye inflammations fell from 7.0 to 1.5 per thousand.

RATIOS OF ADMISSION TO SICK REPORT, DISCHARGE, DEATH, AND CONSTANTLY NON-EFFECTIVE OF THE UNITED STATES ARMY FOR THE DECADE 1886–95.

For the Decade 1886–95.	White.				Colored.				Indian.				Total.			
Mean strength	A. G., 24,301.			S. G., 22,071.	A. G., 2,379.			S. G., 2,188.	A. G., 227.			S. G., 213.	A. G., 26,907.			S. G., 24,472.
Causes of admission to sick report.	Admissions.	Discharges.	Deaths.	Constantly non-effective.*	Admissions.	Discharges.	Deaths.	Constantly non-effective.*	Admissions.†	Discharges.†	Deaths.†	Constantly non-effective.†	Admissions.	Discharges.	Deaths.	Constantly non-effective.*
Special.																
Vaccinia	33.76	0.004	....	1.06	26.24	....	....	0.76	106.25	....	....	4.14	33.72	0.004	....	1.00
Typhoid fever	5.94	.01	0.64	.91	2.10	....	0.50	.29	.47	....	....	.02	5.55	.01	0.62	.84
Malarial infections	96.20	.09	.14	2.48	64.50	0.04	.38	1.74	32.91	....	....	.47	92.82	.08	.16	2.40
Rheumatic fever	5.11	.07	.02	.59	5.76	.04	....	.53	4.23	0.44	....	.58	5.16	.07	.02	.58
Tuberculosis of the lungs	2.93	1.52	.44	.70	3.93	1.85	.84	.97	25.39	11.44	7.04	3.55	3.21	1.63	.54	.75
Syphilis	17.45	1.98	.02	1.68	20.98	3.36	.04	2.02	15.51	2.64	....	1.76	17.75	2.11	.02	1.71
Gonorrhœa	38.97	.26	....	2.30	32.41	.04	....	1.52	63.00	....	....	3.17	38.60	.24	....	2.24
All venereal diseases	75.89	2.30	.02	5.26	78.48	3.40	.04	5.21	98.26	2.64	....	5.77	76.32	2.40	.02	5.26
Alcoholism and direct results	42.37	.07	.22	.47	4.89	.04	....	.05	4.70	....	....	.07	38.69	.07	.20	.43
Neuralgia	24.69	.16	....	.62	36.94	.04	....	.57	15.05	....	....	.17	25.70	.14	....	.62
Tonsillitis	41.35	.004	.01	.66	54.49	....	....	.73	29.62	....	....	.41	42.42	.004	.01	.66
Colic and constipation	32.10	.02	....	.29	49.18	.04	....	.41	31.50	....	....	.34	33.62	.02	....	.30
Diarrhœal diseases	115.68	.22	.13	1.34	99.75	.17	.13	1.14	45.61	....	....	.55	113.65	.21	.13	1.32
Diseases of the heart	5.79	1.36	.42	.53	4.94	1.18	.25	.30	2.35	.88	.44	.16	5.69	1.34	.41	.51
Coryza	33.56	....	....	.29	41.36	....	....	.30	12.69	....	....	.11	34.08	.....	....	.29
Bronchitis	67.94	.23	.02	1.37	69.26	.17	....	1.20	56.89	....	....	.82	67.97	.22	.02	1.35
Pneumonia	3.88	.03	.66	.41	6.90	.08	1.51	.60	10.34	....	.88	.70	4.20	.06	.74	.43
Diseases of the kidneys	1.72	.20	.23	.21	2.83	.29	.34	.22	.....	....	....	....	1.80	.20	.24	.21
Rheumatism and myalgia	73.28	1.59	.02	3.65	116.33	2.02	....	4.56	50.78	1.32	....	1.54	76.94	1.63	.02	3.71

Boils and abscesses	43.74	.02	.004	.99	26.51	.04	....	.67	42.31	....	....	1.21	42.18	.02	.004	.97
Conjunctivitis	11.86	.06	....	.32	14.49	.21	....	.45	44.67	....	....	1.21	12.38	.07	....	.34
All diseases of the eye	17.95	.98	....	.78	26.74	1.13	....	1.04	62.06	.44	....	1.98	19.13	.99	....	.82
All diseases of the ear	7.67	.54	.004	.34	3.70	.13	....	.16	8.46	....	.44	.16	7.32	.50	.01	.33
Contusions and sprains	130.04	.23	.01	3.33	145.86	.21	.04	3.36	128.82	....	....	3.02	131.46	.23	.01	3.33
Dislocations	2.57	.11	.004	.20	1.87	.13	....	.11	6.11	....	....	.52	2.54	.11	.004	.20
Fractures, not gunshot	6.99	.52	.10	1.20	5.12	.34	.08	.88	11.75	....	1.76	1.52	6.86	.50	.11	1.17
Wounds, not gunshot	50.21	.20	.05	1.48	68.07	.21	.08	1.99	91.20	....	....	2.10	52.16	.20	.05	1.53
Wounds, gunshot	3.30	.64	.96	.57	7.27	.80	1.60	.97	7.05	.88	4.84	1.05	3.69	.66	1.05	.61
Grouped.																
Infectious diseases, general and local	302.66	4.15	1.73	13.18	276.73	5.76	2.40	11.55	350.26	15.41	7.04	17.45	300.76	4.39	1.84	13.09
Diseases of nutrition, general	2.55	.59	.09	.23	2.10	.38	.04	.18	1.41	....	.44	.03	2.50	.56	.09	.22
Diseases of the nervous system	96.67	3.12	.79	2.32	77.07	2.14	.46	1.57	41.38	1.32	.44	.68	94.44	2.02	.76	2.24
Diseases of the digestive system	278.10	.75	.65	4.40	300.59	.76	.38	4.08	180.54	....	....	2.57	279.26	.75	.62	4.35
Diseases of the circulatory system	7.14	1.71	.51	.69	5.30	1.26	.50	.36	2.35	.88	.44	.16	6.93	1.66	.51	.66
Diseases of the respiratory organs	113.00	.58	.78	2.49	130.55	.34	1.81	2.57	92.15	1.32	.88	2.46	114.39	.56	.87	2.50
Diseases of the genito-urinary system	11.33	.81	.24	.85	14.49	.97	.34	.93	7.99	.44	....	.21	11.58	.82	.25	.85
Diseases of the lymphatic system and ductless glands	5.35	.07	.004	.44	6.95	....	....	.47	11.28	....	....	.93	5.54	.06	.004	.45
Diseases of the muscles, bones, and joints	79.16	2.67	.01	3.74	121.41	3.24	.04	4.89	53.60	1.76	....	1.38	82.70	2.71	.01	3.83
Diseases of the integument and subcutaneous connective tissue	79.47	.23	.02	2.11	50.47	.25	.08	1.58	71.93	....	....	2.19	76.81	.23	.02	2.06
Diseases of the organs of special sense	27.53	1.65	.01	1.27	31.45	1.39	....	1.26	72.40	.44	.44	2.19	28.27	1.62	.01	1.28
Unclassified	2.79	....	.004	.07	5.21	....	....	.08	2.82	....	....	.01	3.00	.....	.304	.07
General injuries	3.25	.02	1.02	.08	1.87	.04	.42	.04	.....	....	.44	....	3.10	.03	.96	.07
Injuries to special parts	245.13	3.36	1.26	8.47	289.26	3.45	1.98	9.35	302.30	2.64	6.60	9.76	249.57	3.36	1.37	8.57
Total for diseases	1,005.77	16.34	4.84	31.80	1,022.31	16.48	6.05	29.53	888.11	21.57	9.68	30.27	1,006.22	16.39	4.99	31.62
Total for injuries	248.38	3.39	2.28	8.54	291.13	3.49	2.40	9.39	302.30	2.64	7.04	9.76	252.67	3.39	2.33	8.64
Total for all causes	1,254.15	19.72	7.12	40.34	1,313.43	19.97	8.45	38.92	1,190.41	24.21	16.72	40.03	1,258.89	19.78	7.32	40.26

* For 1887-95—nine years of decade. † For 1891-95—four years of decade.

TABLE SHOWING THE AVERAGE STRENGTH, ADMISSIONS INTO HOSPITAL, DEATHS, NUMBERS INVALIDED AND CONSTANTLY SICK AMONG THE BRITISH TROOPS STATIONED IN THE UNITED KINGDOM DURING THE YEAR 1897, WITH THE RATIOS PER 1,000, THE STRENGTH, AND THE AVERAGE RATIOS FOR TEN YEARS.

Average Strength in Annual Returns, 96,526. Average Strength, Including Men Detached, 98,290.

DISEASES.	Admission to hospital.	DEATHS.			Invalids discharged from the service.	Average number of constantly sick.	RATIO PER 1,000.				AVERAGE RATIO PER 1,000 FROM 1887 TO 1896.			
		With the regiment.	Absent from the regiment.	Total.			Admissions.	Deaths.	Invalids finally discharged.	Constantly sick.	Admissions.	Deaths.	Invalids finally discharged.	Constantly sick.
General Diseases.														
Smallpox	....	..	..	..	....	.....	....	....	....	....	0.1	....	....	0.01
Other eruptive fevers	1,057	10	..	10	....	92.43	11.0	0.10	....	0.96	8.6	0.06	....	.65
Influenza	591	..	..	..	....	17.25	6.1	....	....	.18	16.1	.03	....	.44
Diphtheria	44	4	..	4	....	2.37	.5	.04	....	.02	.7	.02	....	.05
Enteric fever	88	20	1	21	....	15.11	.9	.21	....	.16	1.3	.25	....	.21
Other continued fevers	360	1	..	1	....	13.59	3.7	.01	....	.14	4.1	.01	....	.15
Cholera	....	..	..	..	....	.05								
Dysentery	47	1	..	1	5	4.15	.5	.01	.05	.04	.6	.02	.04	.06
Yellow fever	....	..	..	..	....	.....	....	....	....	....	....	....	....	....
Malarial fever	500	2	..	2	1	19.27	5.2	.02	.01	.20	6.1	.01	.02	.22
Septic diseases	54	3	..	3	....	3.69	.6	.03	....	.02	1.8	.08	....	.12
Tuberculous diseases	236	45	6	51	142	40.92	2.4	.52	1.44	.44	3.8	.85	1.91	.60
Syphilis, primary	3,218	..	..	..	....	327.42	33.3	....	....	3.39	59.2	....	.01	5.60
Syphilis, secondary	2,919	5	1	6	102	316.11	30.2	.06	1.04	3.27	35.9	.05	.87	3.55
Gonorrhœa	6,176	..	..	..	16	464.99	64.0	....	.16	4.82	86.2	....	.05	5.88
Hydrophobia														
Parasitic diseases	2,277	1	..	1	....	73.75	23.6	.01	....	.76	26.3	....	...	.7

Scurvy	1	..	..	..	....	.02	....	....	....	....	.1			
Alcoholism	158	2	..	2	....	5.33	1.6	.02	....	.06	2.2	.03	.01	.07
Rheumatism	2,515	7	..	7	63	167.57	26.1	.07	.64	1.74	34.6	.05	.64	2.19
Debility	654	..	..	..	90	49.19	6.8	....	.92	.51	7.2	.01	.90	.50
Other general diseases	544	11	..	11	42	36.56	5.6	.11	.42	.38	5.2	.12	.19	.35
Local Diseases.														
Diseases of the nervous system: Nervous	623	17	2	19	125	48.09	6.5	.19	1.27	.50	7.2	.30	1.13	.49
Diseases of the nervous system: Mental	121	2	..	2	86	18.30	1.3	.02	.88	.19	1.3	.02	.90	.23
Eye	1,066	..	..	..	85	65.66	11.0	....	.87	.68	11.4	....	.69	.69
Other organs of special sense	908	2	..	2	142	63.81	9.4	.02	1.44	.66	7.8	.01	.85	.50
Circulatory system	1,053	31	4	35	368	104.68	10.9	.36	3.74	1.08	9.9	.37	3.50	.96
Respiratory system	4,435	51	4	55	73	229.37	46.0	.56	.74	2.38	60.2	1.16	.81	3.02
Digestive system	9,085	17	1	18	179	305.83	94.1	.18	1.82	3.17	105.7	.32	.98	3.20
Lymphatic system	956	..	..	..	14	105.93	9.9	....	.14	1.10	15.8	.01	.12	1.70
Urinary system	186	11	1	12	37	19.96	1.9	.12	.38	.21	2.2	.14	.27	.20
Generative system	2,330	1	..	1	38	162.19	24.1	.01	.39	1.68	34.2	.01	.29	2.24
Organs of locomotion	1,239	2	..	2	197	89.10	12.8	.02	2.01	.92	8.3	.02	1.06	.65
Connective tissue	2,350	1	..	1	6	101.92	24.3	.01	.06	1.06	23.6	.01	.08	1.05
Skin	5,029	..	..	..	28	222.47	52.1	....	.29	2.30	46.3	....	.21	2.01
Injuries.														
General	35	..	..	27	2	2.86	.4	.28	.02	.03	.2	.35	.01	.01
Local	10,616	35	1	36	110	457.86	110.0	37	1.12	4.74	98.5	.32	.73	4.06
In action														
Poisons	14	6	..	6	2	.97	.1	.06	.02	.01	.1	.05	....	.01
No appreciable disease	356	..	..	..	....	14.19	3.7	....	....	.15	3.1	....	....	.10
Cause unknown (refers to death only)														
General total	61,841	315	21	336	1,953	3,662.96	640.6	3.41	19.87	37.95	735.9	4.68	16.27	42.51

DECREASE OF RATES FOR THE GERMAN ARMY.

Year.	Morbidity per 1,000.	Mortality per 1,000.	Invalided per 1,000.
1879–80	1,174.8	4.82	
1880–81	1,136.2	4.82	
1881–82	1,135.5	4.53	
1882–83	849.6	4.25	20.6
1883–84	830.1	4.16	20.7
1884–85	850.3	3.93	20.4
1885–86	849.2	3.73	23.9
1886–87	808.0	3.79	20.6
1887–88	804.1	3.24	21.5
1888–89	758.9	3.19	19.6
1889–90	897.2	3.30	25.9

According to Boisseau, the mortality of the British army on the home station prior to 1853 was 17.5 per thousand strength. After the improvement in the sanitary surroundings of the soldier in that service following the Crimean war, the rates for death and sickness were much diminished, and for the decade 1875–84 had fallen to 7.20 deaths per thousand strength. In 1889 the death rate was 4.57 and the sickness 730.4. In 1890 the deaths rose to 5.53 and the sick rate to 810. For the decade 1887–96 the admissions were 735.9 and the ratio of deaths per thousand strength was 4.68. In 1897 there died only 3.42 per thousand of strength, while the admission rate had fallen to 640.6 per thousand strength.

The reduction in the rates of sickness and death in the Italian army during the past twenty-five years has been steadily progressive and probably presents less fluctuation than is the case in any other military service.

Year.	Admissions to hospital or infirmary per 1,000.	Death rate per 1,000.	Year.	Admissions to hospital or infirmary per 1,000.	Death rate per 1,000.
1875	1,031	13.3	1887	760	8.7
1876	1,001	11.2	1888	732	8.7
1877	987	10.6	1889	749	8.0
1878	947	10.6	1890	796	7.5
1879	936	9.9	1891	811	9.0
1880	935	11.0	1892	758	7.1
1881	928	10.6	1893	735	6.6
1882	833	10.2	1894	723	5.2
1883	842	11.8	1895	743	7.0
1884	779	11.6	1896	741	5.8
1885	791	10.3	1897	694	4.2
1886	798	9.3			

Viry gives the following rates for mortality in the French army as illustrating the better observance of the rules of military hygiene.

Period.	Mortality per 1,000 strength.	Period.	Mortality per 1,000 strength.
1812	27.9	1873–81	9.0
1820–25	21.4	1883	8.15
1846	19.	1889	5.39
1846–58	16.	1890	5.81
1862–72	13.		

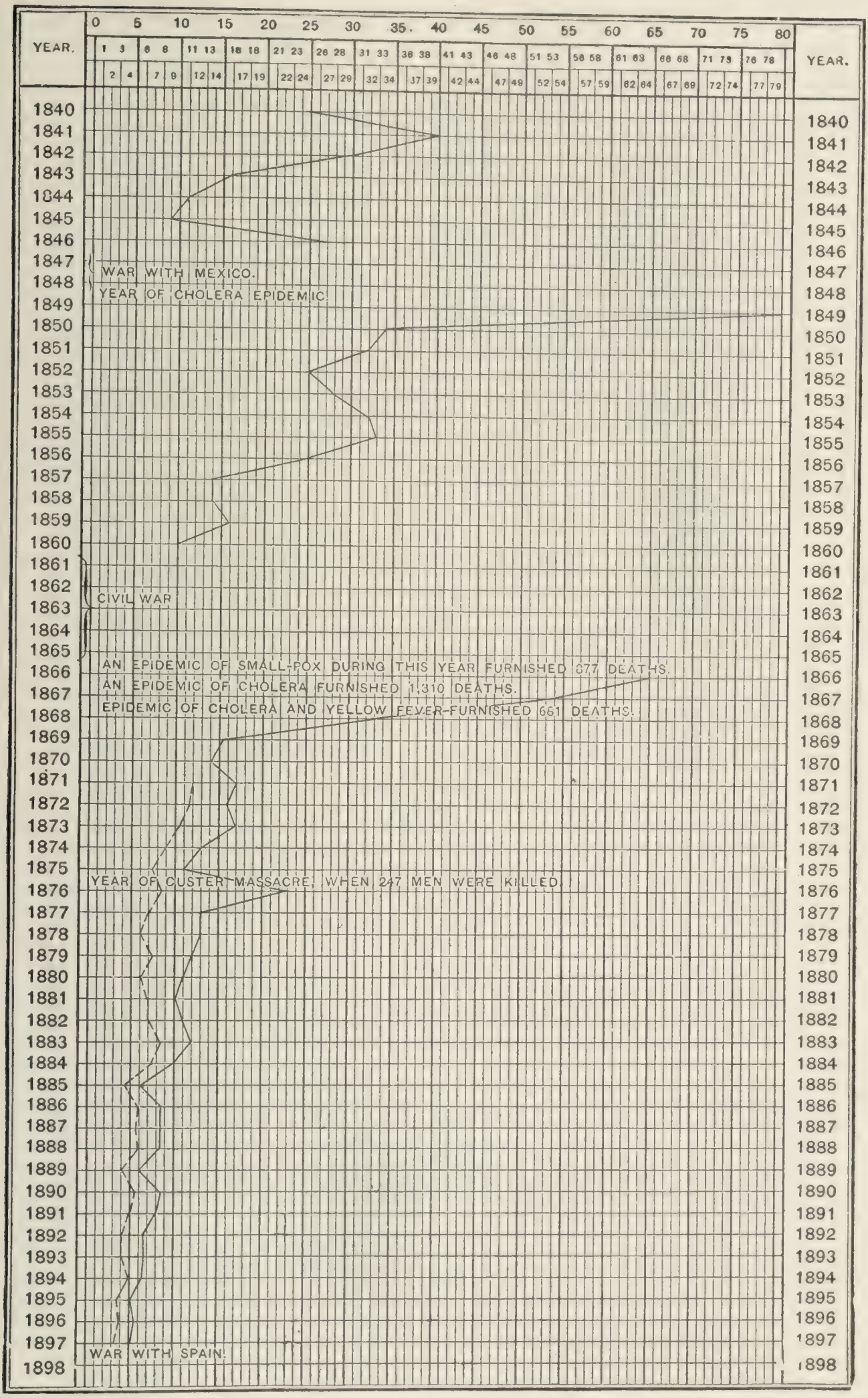


FIG. 321.—Chart Showing Reduction in Death Rate, per Thousand Strength, in the United States Army, under Conditions of Peace, for the Period 1840–1898.

Death rate from all causes ———————— Death rate from disease alone — — — — — —

Dewey states that in the French service the average annual death rate was 8.43 per thousand strength for the seven years 1880–86, and that it sank to a yearly average of 6.63 for the seven succeeding years. This decreased death rate is naturally consequent to a lessened amount of sickness, as the following figures from Marvaud illustrate:

Period.	1862–65.	1866–69.	1884–87.
Admissions to hospital per 1,000 strength (admissions to infirmaries and cases treated in quarters not included)	264.5	259.5	177.0
Rate of constant non-effectives per 1,000 strength	23.3	22.1	14.0

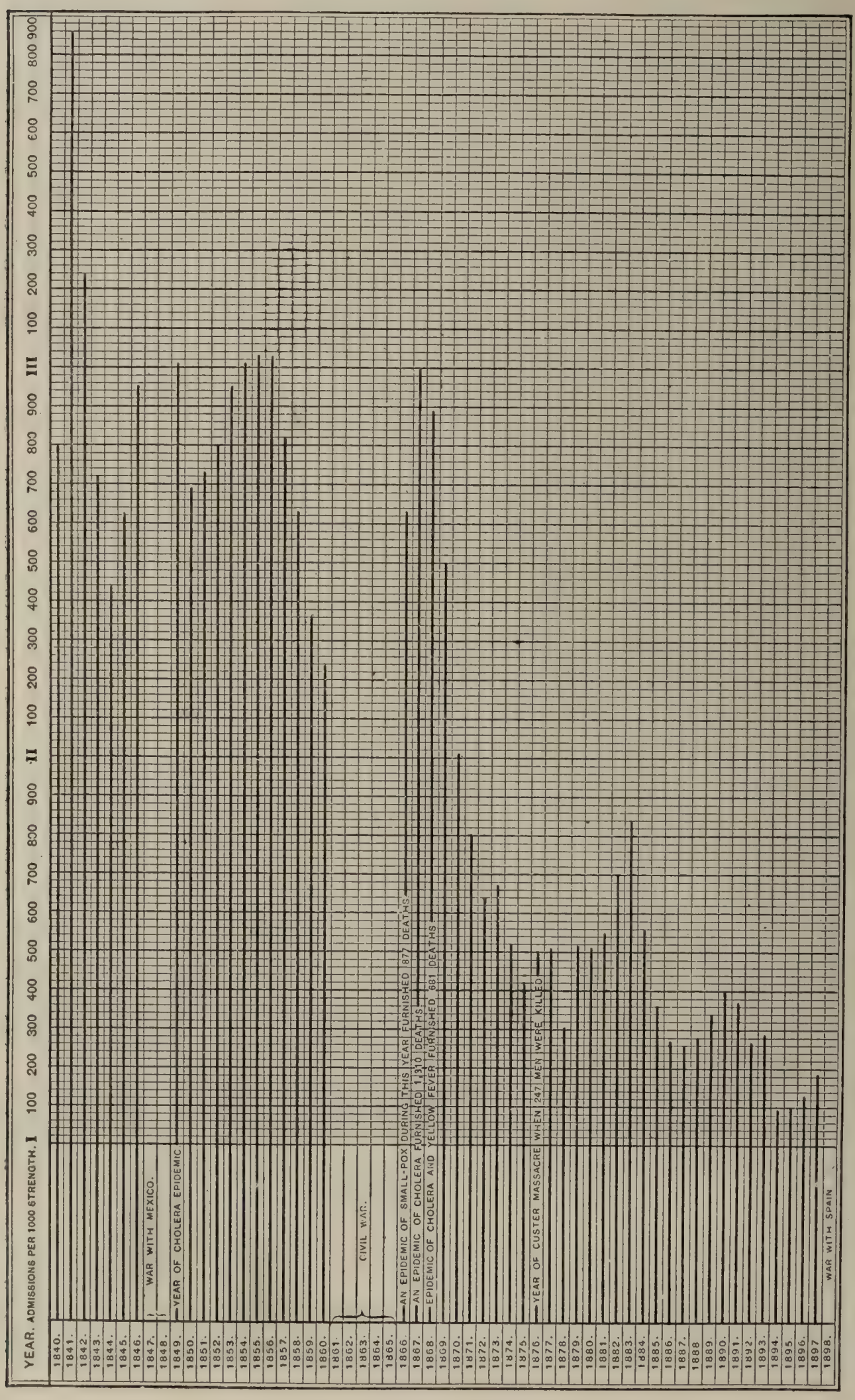


FIG. 322.—Chart Showing Reduction in the Rate, per Thousand Strength, for Admissions to Sick Report for All Causes, in the United States Army, During Conditions of Peace, for the Period 1840–1898. (The Roman numerals I, II, and III designate each thousand of admissions; the figures 100, 200, 300, etc., show each hundred admissions.)

Lindley, writing in 1892, states that during the preceding forty years the death rates in the Prussian and Belgian armies had shrunk to two-fifths, the English and Russian rates had fallen to one-half, and the French rate had diminished to one-third. These figures may probably be accepted as being approximately correct.

The lamentable conditions revealed by the above statistics as existing until even within the present generation, in the armies of all nations, were undoubtedly largely due to ignorance of first causes of disease, by which measures for its prevention could not be intelligently applied, as well as to an insufficient knowledge of hygiene and lack of appreciation as to its value from a military standpoint. An additional factor of no mean importance, however, was to be found in the former anomalous and inferior condition of the medical officer, his lack of authority to recommend in sanitary matters and his powerlessness to control or remedy existing conditions. It was long held that his duties were merely to care for the sick and wounded, and any recommendations bearing on the general care or management of the men were deemed intrusive and as such usually disregarded and resented. The comparatively recent conferring of advisory powers upon the medical officer for sanitary purposes has undoubtedly been a potent factor in the gradual betterment of the sanitary condition, and hence efficiency, of the soldier; and when the former is invested with actual authority upon all matters bearing upon the health of troops, with executive powers as well as advisory privileges, a still further improvement in this direction may be expected.

Although during the past one or two generations a marked diminution has occurred in the sickness, mortality and non-efficiency among the troops of the United States and those of European nations upon the home stations, the same unfortunately cannot be said with regard to white troops doing colonial duty in tropical climates. For such troops these rates continue to be high, and no great improvement in their sanitary state, as evidenced by statistics, appears to have resulted for many years. Since the hygienic requirements for each military establishment, wherever its troops may be stationed, must be accepted as being the same for all circumstances, the conclusion is obvious that climatic conditions in the tropics furnish a potent obstacle against a constant reduction in rates proportionate to that which has occurred on the home stations. While undoubtedly much has been done during the past generation to render military service in hot countries less inimical to life and health, the fact none the less remains that sanitary progress in the low latitudes has fallen far short of that obtaining in more temperate climates. It is evident that figures illustrating this point are best furnished by the records of the British service, and these are briefly compared as follows:

	Period.	Admissions to hospital per 1,000.	Deaths per 1,000.	Days lost per man.
West Indies	Decade 1875–84	885.0	15.36	16.26
	Decade 1886–95	1,115.7	9.23	22.67
	Year 1896	1,190.2	6.19	28.69
Ceylon	Decade 1875–84	1,085.4	14.51	20.97
	Decade 1886–95	1,004.1	11.38	21.10
	Year 1896	1,321.1	8.23	23.76

	Period.	Admissions to hospital per 1,000.	Deaths per 1,000.	Days lost per man.
China	Decade 1875–84	1,030.4	10.53	18.07
	Decade 1886–95	1,256.0	11.44	22.41
	Year 1896	1,856.5	7.48	32.05
India	Decade 1875–84	1,482.9	17.43	23.06
	Decade 1886–95	1,453.5	15.52	30.26
	Year 1896	1,386.7	15.29	34.35
Egypt and Cyprus	Decade 1875–84	No	figures gi	ven.
	Decade 1886–95	1,069.7	16.30	24.56
	Year 1896	822.3	13.28	23.11
Straits Settlements	Decade 1875–84	No	figures gi	ven.
	Decade 1886–95	1,079.4	7.27	25.58
	Year 1896	1,074.7	8.88	26.46

From these figures it is evident that while there was a considerable diminution in the morbidity and mortality rates for the West Indies and Ceylon during the past twenty years, but little improvement has occurred in the general rate for China, Egypt and Cyprus. In India, a country long occupied by a large military force of Europeans and one in which the greatest improvement might reasonably be expected to have occurred, the rates are practically what they were two decades ago—the death rate of British troops at home having fallen from 7.20 to 3.58 per thousand, while the mortality for India fell only from 17.43 to 15.29 during the same period. Further, the several rates for the Straits Settlements have actually increased during the past ten years.

In this respect the experience of Great Britain is duplicated by that of the French service, in which in 1862 the mortality for troops throughout France was 9.42 and for those in Algeria 12.21 per thousand; while in 1890 the death rate for troops at home was 5.81 and for those in Algeria 11.94 per thousand.

War as Affecting the Health of Armies.—The rates of sickness and death for troops during campaign, independent of the circumstances which accompany conflict, are chiefly influenced by the sanitary standards maintained, and, as already stated, it is difficult to cite campaigns in which the death rate from sickness has not been greater than that from casualty.

The diseases observed during continued warfare, according to Laveran, are largely brought about by four chief influences: atmospheric, exhalations from the soil, evil condition of the latrines and poor food. The atmospheric exposure to which the soldier is often subjected is one of the greatest hardships of a campaign. Sleeping on the bare ground and often drenched with rain, standing in trenches exposed to snow and cold, or making long marches under a tropical sun, are a few of the influences by which he is debilitated and his constitution impaired. Service in a malarious country is notoriously productive of disease, while ill policed sinks are potent factors in the occurrence of typhoid and dysentery. The influence of insufficient or improper food in lowering the resisting powers of the soldier is well recognized. Excessive fatigue and moral influences also play an important part in determining the sick rate, it being well established that victorious forces have less sickness than armies which

have been beaten and demoralized. The endemic and epidemic diseases of an occupied country, together with the influence of a change of climate,

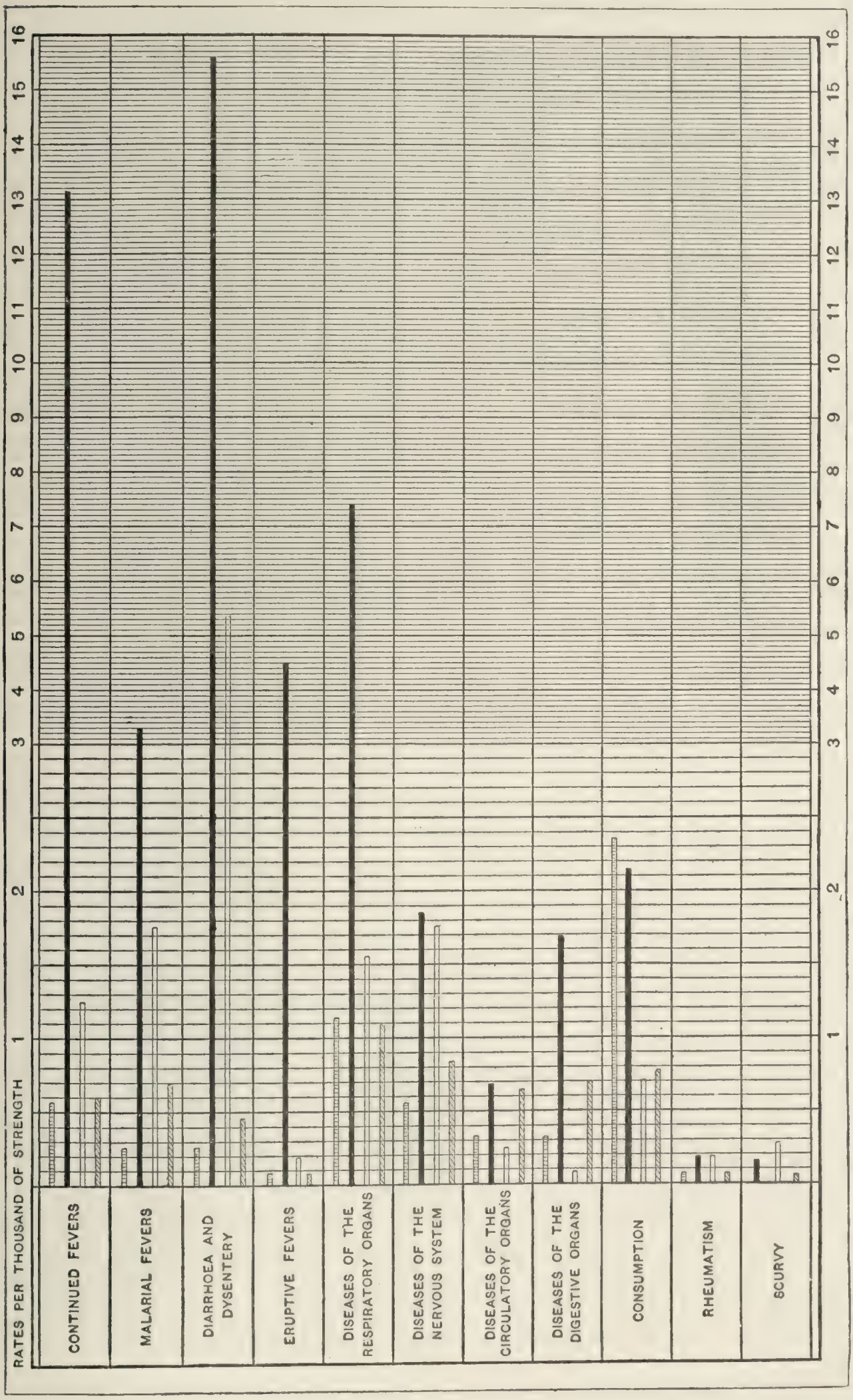


FIG. 323.—A Comparison of the Annual Mortality Rates Caused by Certain Diseases in Various Groups of Men of the Military Age.
United States army before the Civil War
United States army after the Civil War
United States civilians
United States army during the Civil War
(Adapted from the "Medical and Surgical History of the War of the Rebellion.")

aggravate also to a considerable degree the sickness and mortality of an expeditionary corps.

For our own service the influence of hostilities upon mortality from

disease is well illustrated in the preceding chart, showing, as it does, the rates for certain affections in the United States army, during the Civil War, for periods before and subsequent to that war, and also as compared with the death rates for the corresponding class in civil life. As compared with the mortality from continued fevers—which affections may be considered, in the light of present knowledge, as chiefly of typhoid nature—war brought about an increase of tenfold. Malarial diseases were doubled and diarrhœa and dysentery tripled. Deaths from eruptive fevers became about twenty-two times as frequent as they were before the war, while those from diseases of the respiratory organs were more than quadrupled. Camp life appeared to have little influence in affecting the mortality from nervous affections. Deaths from diseases of the circulatory and digestive organs were practically doubled in frequency, as was also the mortality from consumption. Rheumatism, as regards a fatal termination, and contrary to expectation, was not increased; but scurvy—the former bane of armies in the field—was doubled. The average annual death rates from disease during the entire war was 53.48 per thousand strength among white troops, while it was 18.98 for these troops during the eighteen years before the war, excluding the two years of hostilities against Mexico, and only barely over 6 per thousand for the decade subsequent to the war.

The following table shows the influence of the war with Spain upon the rates for sickness and death, as regards the prevalence of certain classes of diseases:

TABLE GIVING FIGURES FOR THE COMPARISON OF THE YEAR OF PEACE, 1897, WITH THE YEAR OF WAR, 1898. UNITED STATES ARMY.

Group.	Admissions per 1,000 Strength.		Constantly Non-Effective per 1,000 Strength.		Deaths per 1,000 Strength.		Discharges for Disability per 1,000 Strength.		Total Losses per 1,000 Strength.	
	1897.	1898.	1897.	1898.	1897.	1898.	1897.	1898.	1897.	1898.
Infectious diseases, general and local	326.10	1,034.97	12.59	57.90	1.35	15.99	1.28	2.14	2.63	18.13
Diseases of nutrition	2.05	3.49	.19	.21	....	.09	.29	.13	.29	.22
Diseases of the nervous system	56.94	52.81	1.63	1.33	.33	.92	1.79	.86	2.12	1.78
Diseases of the digestive system	244.05	505.71	3.75	7.01	.55	3.11	.55	.58	1.10	3.69
Diseases of the circulatory system	4.68	6.73	.41	.60	.37	.49	.95	.96	1.32	1.45
Diseases of the respiratory system	77.74	144.50	1.64	2.04	.22	.96	.40	.26	.62	1.22
Diseases of the genito-urinary system	9.76	11.77	.80	.67	.22	.24	.44	.43	.66	.67
Diseases of the lymphatic system and ductless glands	2.36	3.22	.17	.17	.04	....	....	.02	.04	.02
Diseases of the muscles, bones and joints	72.52	77.34	2.85	2.70	....	....	.31	1.33	1.31	1.33
Diseases of the integument and subcutaneous connective tissues	72.55	60.57	1.70	1.06	....	.30	....	.04	....	.34
Diseases of the organs of special sense	24.47	17.39	.92	.79	.04	....	.58	.62	.62	.62
Unclassified	2.44	19.17	.09	.59	.04	....	....	.02	.04	.02
Total for diseases	896.53	1,937.74	26.73	69.09	3.14	24.94	7.60	7.40	10.74	32.34
Total for injuries	290.08	209.23	9.12	13.74	1.97	8.41	2.01	4.18	3.98	12.59
Total for all causes	1,186.61	2,146.94	35.85	82.83	5.11	33.35	9.61	11.58	14.72	44.93

As showing the effect of campaign on sick rates the British Afghanistan expedition, in 1879, furnishes a good example. The rates per thousand for 1878, the year preceding the war, and the two years of the war, are as follows:

Year.	Admissions for disease per 1,000 strength.	Deaths from disease per 1,000 strength.
1878	340.1	2.82
1879	1315.5	74.63
1880	1107.1	30.64

All things being considered, it is safe to assume that the outbreak of hostilities will be followed by a vast increase in the death rate from disease, probably from six to twelve or more times that normally occurring in peace; the proportion naturally varying with the character of the campaign, the climatic conditions to be encountered, the local diseases to be undergone, the efficiency of the commissary and transportation departments, the employment of seasoned or unseasoned troops and many other factors. The rate of admissions to sick report from disease in time of war is not, however, increased proportionately to the death rate—a fact sufficiently proving the more serious nature of the diseases affecting troops in the field. As to the rate for non-efficiency, this is largely dependent upon the ratio for admissions, and naturally bears in its fluctuations a close relationship to the prevalence and character of disease. If the records of the Spanish-American war be accepted as typical in this respect, no great difference in the rates for discharge by reason of disability, in peace or war, may be anticipated.

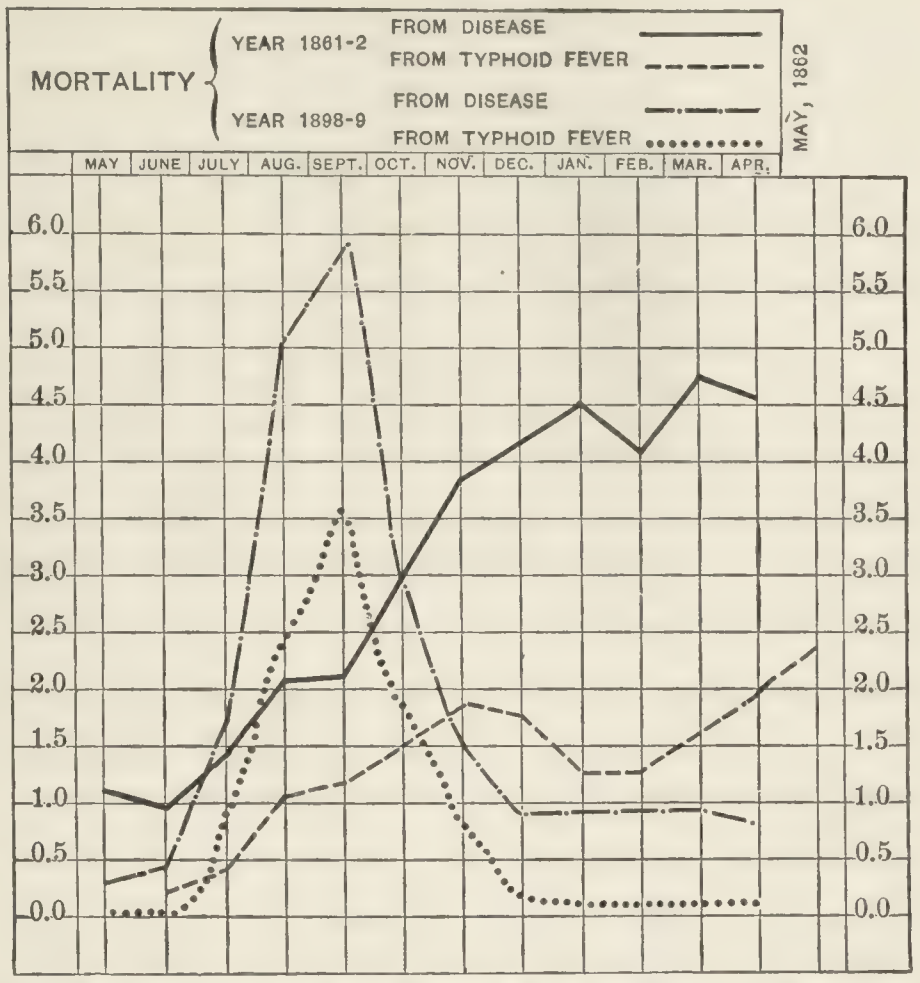


FIG. 324.—Mortality from all Diseases and from Typhoid Fever during the War with Spain and during the Corresponding Period of the Civil War. (After Sternberg.)

In comparing the results of the Spanish-American war with the corresponding period of the Civil War the advantage is much in favor of the former, although the progress of disease, by months, is quite dissimilar. It is particularly noticeable that not only was the death rate during the war with Spain reduced by 43.9 per cent. as compared with the struggle of the previous generation, but the amount of epidemic typhoid, largely resulting from the inexperience of the volunteer troops, rapidly decreased as a result of scientific sanitary measures enforced as soon as the magnitude of the typhoid outbreak was fully understood.

COMPARISON OF MONTHLY DEATH RATES PER 1,000, FROM DISEASE, DURING THE FIRST YEAR OF THE CIVIL WAR AND THE WAR WITH SPAIN.

Months.	1861–62.			1898–99.		
	Mean strength.	Number of deaths.	Ratio per 1,000 of M.S.	Ratio per 1,000 of M.S.	Number of deaths.	Mean strength.
May	16,161	18	1.11	0.26	42	163,726
June	66,950	55	.82	.44	90	202,526
July	71,125	106	1.49	1.72	451	362,613
August	112,359	242	2.15	5.21	1,400	268,507
September	165,126	365	2.21	5.89	1,541	261,824
October	256,884	725	2.82	3.17	809	255,000
November	301,848	1,145	3.79	1.51	365	242,000
December	343,184	1,471	4.29	.84	201	240,000
January	352,760	1,593	4.52	.85	180	211,000
February	327,734	1,346	4.11	.87	156	180,000
March	328,878	1,575	4.79	.90	123	136,000
April	410,416	1,881	4.58	.71	80	113,000
Annual	229,452	10,522	45.86	25.73	5,438	211,350

As already intimated, so many factors combine to determine mortality from sickness in campaign that any attempt at the close comparison in this respect of different wars—carried on under entirely different conditions—can yield only misleading results. General deductions can of course be drawn, and hence the following figures may be of advantage as well as interest:

DEATHS FROM DISEASE DURING CERTAIN WARS OF THE PRESENT CENTURY.
(After Bradford.)

Name of War.	Nation.	Year or period.	Mortality from disease per 1,000 strength.
Walcheren expedition	Great Britain	1809	346.9
West Coast of Africa	Great Britain	1824	690.0
Mexican	United States	1846–48	100.0
Crimean	Great Britain	1854	230.0
Chinese	France	1862	118.0
Civil War	United States	1862	40.0
Civil War	United States	1863	60.0
Franco-Prussian	Germany	1870–71	18.6
Afghanistan	Great Britain	1878–80	93.7
Soudan	France	1888–89	280.0
Madagascar	France	1895	300.0
Chino-Japanese	Japan	1895	14.8
Spanish-American	United States	1898	25.0

With regard to the results of campaigning under tropical conditions, the most satisfactory data are naturally furnished by the two great colonizing powers, Great Britain and France. The figures given for these services are so widely dissimilar, however, as to furnish no foundation for any general conclusions based upon them both. For purposes of comparison merely, they are certainly valuable—the French having little reason to be proud of their sanitary showing, as evidenced in the following table.

TABLE OF MORTALITY FROM DISEASE IN MORE RECENT CAMPAIGNS IN TROPICAL COUNTRIES, SHOWING RATE OF DEATH PER 1,000 STRENGTH. (After Bradford.)

British Expeditions.			French Expeditions.		
Soudan	1889	0.6	Tonkin	1884	60.0
Mashonaland	1876	2.0	Tunis	1881	61.0
Suakim	1885	2.2	Mexico	1862–63	71.0
Soudan	1885–86	4.1	Tonkin	1885	79.0
China (Talien-wan)	1860	5.4	Dahomey	1893	87.0
Ashanti	1895–96	5.6	Tonkin	1886	99.0
Egypt	1882	5.7	Tonkin	1887	106.0
Abyssinia	1867–68	12.1	Cochin-China	1863	107.0
Galeika Gaika	1877–78	14.0	Soudan	1887–88	116.0
China Field Force	1860	14.9	Cochin-China	1862	117.0
Matabeleland	1896	16.5	China	1862	118.0
Ashanti	1874	17.4	Tonkin	1888	133.0
Zululand	1879	24.8	Soudan	1885–86	200.0
Chitral	1895	25.1	Soudan	1886–87	220.0
Nile	1884–85	26.4	Soudan	1887–88	225.0
Dongola	1896	46.6	Soudan	1888–89	280.0
Afghanistan	1878–80	93.7	Madagascar	1895	300.0

The casualties of the recent French expedition in Madagascar are thus given by Gayet:

Killed by the enemy	7
Wounded	94
Deaths from sickness	5,600

Sick, more than 15,000, or 85 per cent. of the whole force.

From the table given above it will be observed that with the exception of the Afghanistan campaign, in which the high mortality was largely the result of an outbreak of cholera, the most unhealthful of seventeen English expeditions in warm climates had a lower death rate than the healthiest of an equal number of French campaigns under presumably similar conditions of temperature. The British expedition against the Ashantis in 1874 certainly demonstrated the efficiency of military hygiene under the most unhealthful conditions; and, in the excellent results obtained, the second expedition against this same tribe, in 1896, far surpassed the first. As compared with the French Madagascar expedition, the mortality rate in the second Ashanti expedition was only about one fifty-third of the losses of the French under probably no more unhealthful conditions. In our own expedition against Manila, during the war with Spain, the results were admirable, only 8 per thousand dying from disease. During the Cuban insurrection the Spanish are reported, for the year 1897, to have had a death rate of 36 per thousand from all causes. The admissions to hospital for the same period were 1,900 per thousand, of which 420 per thousand were for malaria. During 1897 the Spanish troops appeared to have suffered but little from yellow fever; this being probably due to an immunity to this disease acquired through previous visitations. That constant exposure to infectious disease of all kinds, and not only yellow fever, does actually exert a seasoning influence on the survivors and reduce their mortality is well known. As illustrating this point, it may be noted that the sick rate of the colored troops during the Civil War fell from 4,092 per thousand during the first year of their service to 2,797 in the last, while their death rate

dropped from 211 to 94 per thousand strength. The total rates for sickness of all troops during the Civil War underwent considerable diminution, as follows:

First year, admissions per 1,000 strength	2,983
Second year, admissions per 1,000 strength	2,696
Third year, admissions per 1,000 strength	2,210

In this connection the chart already given in connection with the influence of race as affecting the prevalence of disease is of interest.

It is not, however, during active wars or on expeditions that the highest mortality is observed among troops in the field. When an army is condemned to inaction through a siege, for purposes of mobilization, or even in cantonments after a laborious expedition, sickness rages with greater violence. The typhus that tried the Crimean army occurred in the winter after the capture of Sebastopol and after conclusion of the armistice; and examples might be indefinitely multiplied in our own service to show that the stationary force during war is an unhealthy force. In January, 1862, the medical director of the Army of the West, then in winter quarters, reported 13.5 per cent. of the total strength as being excused from duty by reason of sickness. In August, 1861, of some troops encamped on the Arlington flats on the Potomac, 33 per cent. were reported as sick with diarrhœa and malarial fever. During the war with Spain the typhoid epidemics, as is well known, occurred in the larger fixed camps. An excellent illustration of this point is found in the condition of the French troops during the Crimean War, a struggle from which so many sanitary lessons have been drawn. According to Rawlinson, estimates as to the sickness among these troops, for the winter of 1854–55, were as follows:

Month.	Strength.	Sick in Hospital.
October	46,000	3,200
November	55,000	5,000
December	65,000	6,000
January	75,000	9,000
February	88,000	8,000

These figures do not include the sick treated in the regimental infirmaries or in the hospitals at Constantinople.

Comparison of Military Medical Statistics.—It is a matter of the greatest difficulty, if not indeed impossible, to compare the sanitary conditions of various armies with accuracy, since their statistical tables are often differently constructed, the physical requirements for recruits are not identical and diverse regulations as to discharge for disability prevail.

In attemping to institute such comparisons it is well to appreciate at the outset that a sick rate can be kept low by excluding the doubtful or milder cases from the benefits of quarters or hospital, and so preventing them from appearing on the official records; that the sick rates, mortality and constant non-efficiency can be held down by a searching system of discharge for disability, and that the total loss—as shown by the sum of the rates for death and discharge—is, in determining the sanitary state of an army, of much more importance than either of its complementary factors.

In comparing the rates of our service with those of foreign armies, the admission rate is the one which, by its magnitude, attracts attention. This higher rate of admissions, however, does not in itself imply a greater prevalence of disease among the troops of the United States; since with us, in contradiction to the practice in other armies, the soldier is officially taken on sick report whenever he is excused by the medical officer from any part of his duty, whatever be the cause. When it is observed, as was the case in the year 1888, that 796.89 admissions per thousand strength from the Italian army resulted in a death rate of 9.31, while 1,270.73 admissions for each thousand United States soldiers for the same period—divided into 621.61 cases admitted into hospital and 649.12 treated in quarters—had a mortality of only 8.15 per thousand, it is evident that the admissions in the two instances, the rates for discharge for disability not varying greatly, do not constitute facts of equal gravity and are therefore not available for comparison.

The rate for constant non-efficiency is obviously largely dependent upon the admission rate and that of discharge for disability, and reflects, to a considerable degree, their variations. Taken by itself the rate is misleading, and it acquires a certain value only when considered in connection with other rates, particularly that for admissions. As between services, for the reasons already given, it is evident that non-efficiency rates are not susceptible of proper comparison.

A consideration of the death rate alone, as a means of comparison between several armies, is wholly unreliable and merely productive of error; since, as above stated, it can be markedly reduced by the removal from the service of those affected with or predisposed to disease.

Of all the ratios which go to determine the healthfulness of an army, as shown by statistics, that giving the discharge for disability is of the greatest importance. In its relation to military morbidity it is at once evident that the admissions to hospital will be largely furnished by the physically less sound, and that a prompt and proportionate diminution in the sick rate must follow the elimination of these weaklings by their discharge from the service. Further, the number of men withdrawn from the aggregate strength of the command—the rate of non-effectiveness from disease or injury—is not a factor of equal importance in all armies and cannot be justly used for purposes of comparison. It undoubtedly embodies the number of admissions and the gravity of the cases so admitted; but it is obvious that the constant non-efficiency as well as the admission rate varies inversely with the rigor of the system of discharge. As to mortality, this also depends upon the physical standard maintained, and, as shown in the German army, a low death rate is naturally consequent to the early elimination of those soldiers who are predisposed to or actually affected with disease. Hence the rate of discharge for disability is the controlling factor in determining the value of the rates of admissions, deaths and constant non-efficiency; while it is itself largely dependent upon the physical standards to which the recruit, before enlistment, is required to conform. To institute accurate comparisons, therefore, a constant, unvarying standard for discharge for disability should obtain in the several military forces to be compared; and such a constant standard does not—and practically cannot—exist. Requirements as to discharge for disability necessarily

vary with the customs of each military service, and, to a certain degree, with the personal equation of each medical officer. As an instance of the former, it may be noted that the Germans are especially assiduous in promptly removing the tuberculous from their armies, while we, on the other hand, maintain a sanitarium for soldiers affected with this disease; and this single source of error, to which might be added many other less aggravated instances, prevents a comparison of the sickness, mortality and non-efficiency upon anything like equal premises. If it be admitted, however, that the physical requirements for the recruits of various armies are approximately the same, the total losses, irrespective of either non-efficiency or admission rate, should afford a somewhat inaccurate but still the most available and satisfactory method of determining the comparative health and physical efficiency of various military services.

The following figures, taken from Marvaud, show the annual sick rates, mortality, loss by discharge and total losses in various European armies for a period about twelve or fifteen years ago:

Name.	Year or period.	Admissions to hospital or infirmary per 1,000 strength.	Death rate per 1,000 strength.	Discharges for disability per 1,000 strength.	Total losses per 1,000 strength.
Belgium	1887–88	338 *	3.9	17.0	20.9
Austria	1887	995 †	6.9	15.0 ‡	21.9
Great Britain (home stations).	1884–85	877	5.2	20.0	25.2
France (home stations)	1888	500	6.1	21.0	27.1
Germany	1883–84	849	3.9	29.0	32.9
Italy	1887	760	8.7	28.0	36.7
Russia	1880–84	845	8.9	31.3	40.2
Spain	1886	....	13.5	30.8	44.3

* General hospitals only. † Including detention in barracks.
‡ Not including temporary invalids.

During the year 1888 the total admissions per thousand strength in the United States army amounted to 1,270.73, the deaths were 8.15 per thousand, the constant non-effectives were 41.91 per thousand, the discharges for disability 27.75 per thousand. These figures give a total annual loss of 35.90—thus making our sanitary showing for that time inferior to that of the above-named nations except Italy, Russia and Spain; all countries notoriously less advanced in matters pertaining to hygiene. It can, however, scarcely be believed that our men, under equal conditions of selection, broke down nearly twice as readily as the Belgian or Austrian soldiers and half again as rapidly as the British soldiers, and hence the conclusion would seem to be inevitable from the above figures that our troops were at that time examined on enlistment with a laxity as to their physical condition which did not obtain in foreign services. This view is further strengthened by the fact that during the same year (1888) out of 742 men discharged on certificates of disability, in 129 instances the disability was specifically declared to have existed prior to enlistment. About this time the large number of discharges for disability attracted the attention of the authorities, and recruiting officers were warned to be more strict in their examinations for enlistment; while a general order required that all men recommended for discharge on account of disability be sent to

the headquarters of each military department, for observation by the chief surgeon, pending final action in their cases. As a result of these requirements the rates for discharge were decreased by nearly one-half in a single year, since which time even further diminution has taken place. For the year 1897 the rate for discharge on account of disability was only 9.61 per thousand as compared with 27.75 during 1888. On comparing the statistics of the above armies for a more recent period—excluding France and Spain, for which countries no later figures are obtainable—the relative status of the United States service is found to be as follows:

Country.	Year.	Admissions to hospital or infirmary per 1,000 strength.	Death rate per 1,000 strength.	Discharges for disability per 1,000 strength.	Total losses per 1,000 strength.
Germany	1895	819.9	2.6	9.0	11.6
Belgium	1897	429.3	2.0	12.4	14.4
United States	1897	1,186.61	5.11	9.61	14.72
Great Britain (home stations)	1897	640.6	3.42	19.87	23.29
Italy	1897	694.0	4.2	21.2	25.4
Russia	1896	314.6	5.40	24.9	30.30
Austria	1897	332.7	4.0	37.5	41.5

It is evident from the above that much has been accomplished during the past decade toward improving the effectiveness and sanitary condition of our army, and it is safe to assume that at the present time the United States soldier not only represents a higher standard of physical excellence but is better cared for than is the man-at-arms of nearly every other military service.

Although, as stated, attempts at the comparison of statistics of different armies are at best necessarily inaccurate and unsatisfactory, within the limits of the same service such action may be both feasible and desirable; the standard for the health of an army, as expressed by Smart, being its own best annual record. Outside of unusual vicissitudes, exposure and epidemics, and of the unsanitary conditions which bring disease and death into the ranks of a military command during campaign, the sanitary surroundings of the soldier do not vary much from year to year except as they are modified by intelligent efforts for their improvement. What has been accomplished in the past should therefore be effected in the present; or satisfactory explanation should be given of the cause of failure, which may thus be converted into a source of protection for the future.

CHAPTER XV.

DISEASES OF THE SOLDIER.

In all its aspects, whatever be the special methods employed for its attainment, military hygiene has for its object the prevention of disease. This, viewed in the abstract and stripped of humanitarian considerations, has relation to military efficiency—which, in its turn, depends upon the proportion of an army which is maintained in a condition vigorously to perform such military duties as may be required. The numerical strength of the forces which contending nations are able to put into the field influences the operations which they perform by equivalence or disparity of numbers. As expressed by Napoleon, "Providence is on the side of the largest battalions." For all practical purposes, it matters little to a commander why his force is small or how it is reduced, if the reason of its inferiority or the cause of its reduction is brought about by agencies beyond his control. But if the agencies are known, if they can be controlled and their effects are remediable, it becomes a matter of the greatest importance to ascertain the way through which they act and how their effects may be limited or obviated, if the causes themselves cannot be removed. Disease operates in reducing strength in various ways; but the point of practical importance to military authorities, and especially to the strategist in the field, is that disease produces absence—this being due to death, to inefficiency from sickness and to the necessity of caring for the sick. Reduction in strength by death, especially to armies in the field, is of course worse in its effects than if the dead men had never been enlisted. Their loss from the military standpoint, which presumes that soldiers are constantly effective, is unexpected, and plans have frequently to be modified accordingly. Upon the deceased have been expended training, provisions and money for which there is no return, yet which were intended to provide an effective force. By the sickness and death of these men the morale of the survivors may be lowered; and in most instances the dead have played an important part in the dissemination of morbific agents among their fellows. Absence from disease is even more fatal to the success of military operations than is absence from death. It is embarrassing as regards strategy and supply when a number of sick have to be retained with an army during active campaign; and the length of time during which such cases require treatment therefore becomes a matter of decided military importance. From the sick, also, disease may be transmitted, and thus the welfare of the majority is menaced. Further, so long as sick soldiers are retained in the service, they require an outlay of money and energy for their care and support, and—of the greatest military importance—the places occupied by them in their respective organizations, so long as they are neither dead nor discharged for disability, cannot be filled by the enlistment

of more healthy and effective individuals. Absence in care of the sick does not now greatly diminish the fighting strength, as was formerly the case, but it implies the necessity for a correspondingly large force of non-combatants, for whose needs additional transportation must be provided—thus sacrificing much of that celerity of movement upon which the success of modern military operations depends.

There are no diseases peculiar to the soldier; those by which he is chiefly affected are such as not infrequently occur among males of the military age in civil life. Military conditions are frequently such, however, that the germs of infectious disease are widely disseminated among an especially susceptible body of men—and hence a larger number are attacked and succumb than would probably have been the case in civil life. Not only is it true that the factors predisposing to deviation from the standards of health are greatly increased in potency, but the course of the disease itself, after its establishment, may be markedly influenced. Thus the diseases developed in the military establishment are characterized by their unusually severe type, the regularity with which outbreaks of some affections recur and the frequent tendency of others to become endemo-epidemic. The prevailing diseases in armies are, naturally, largely acute, and a large proportion of them are zymotic and hence theoretically preventable.

Excluding traumatism, the causes which chiefly impair the health and efficiency of troops, in garrison or during campaign, may be grouped according to their relative importance, as follows:

(1) Diseases of an infectious character, the spread of which, in the military service, is favored by the aggregation of young and susceptible individuals, ignorant or careless in regard to matters of personal hygiene, living under conditions implying intimate personal relationship, constant contact and, frequently, overcrowding. In many instances, the necessities of service require an existence in unhealthful localities favorable to the development of pathogenic micro-organisms, and under circumstances in which their opportunities for dissemination and entrance into the system are much greater than in civil life. In addition, the development of these diseases is often markedly favored by depression of the powers of vital resistance, depending upon great fatigue, exposure to inclemencies of weather, insufficient or improper food, impure water and vitiated air. These diseases assume far greater importance during active service in the field than in garrison, being the chief cause of inefficiency among troops during campaign.

(2) Diseases due to immoral or intemperate habits, as favored by an enforced celibacy, the absence of wholesome home restraint and the monotony often attaching to garrison life. These diseases are factors of the first importance in time of peace in raising the sick-rates of an army, but during active warfare or field service they sink into comparative insignificance. Affections of this character are discussed separately in the chapter devoted to a consideration of the habits of the soldier.

(3) Diseases the specific causative agents of which are unknown, but which appear to be largely excited by exposure to cold, wet and dampness, whether they be found in camp or garrison. These affections have but little tendency toward a fatal result, and their importance from the military standpoint lies in the considerable amount of temporary inefficiency for ser-

vice which they produce. The proportion of soldiers who are temporarily incapacitated for all or part of their duty, from these causes, is always large.

(4) Affections due to extremes of temperature. Such are obviously related to climate and season and are largely influenced by nature of service; being naturally much more frequent among troops on campaign than among those in garrison. Affections of this character are subsequently considered in connection with the hygiene of hot and cold climates.

(5) Diseases produced by food of unsound or unhealthful character. Though possible at any time, such are far more liable to occur during war or in the field, where greater laxity as regards inspection usually prevails and where deterioration in quality is more liable to occur during transportation. Diseases due to such causes have already been considered in connection with the several articles of the ration.

(6) Disease due to an improper dietary; this being largely dependent upon facility of supply and transportation, and hence being obviously more frequent among troops on active campaign or serving at remote, isolated and newly established stations. With the present liberal and scientifically constructed ration, inefficiency from this cause should, in the future, be rare.

(7) Diseases directly induced by military service. These may be of functional or organic nature and are largely dependent upon the muscular labor involved in the execution of military movements, the method of disposing the equipment upon the person and the mental condition often resulting from field service and conflict. Pathological conditions of this character are rarely observed in garrison but are by no means infrequent during campaign. They are sometimes seen, in civil life, in individuals whose callings require the frequent performance of exhausting labor.

In the following consideration of the diseases of the soldier, it is obvious that only such affections as exert a certain positive influence upon military efficiency require discussion. To consider in this connection a number of rare affections, from the liability to which the soldier is no more free than the young man of the military class in civil life and upon the occurrence of which neither positive nor negative influence appears to be exerted by military service, is clearly both unnecessary and undesirable.

I.

THE INFECTIVE DISEASES.

There can be no infectious disease without the presence of the specific causative agent. In addition, there must be an individual susceptibility to the disease, on the part of the person attacked, which permits invasion by and multiplication on the part of the micro-organism concerned. Should anything interfere with the coöperation of these two factors, the disease cannot occur. It is clear, therefore, that for infection to take place the attacking powers must be strong or the resistive agencies weak; and as one or the other of these preponderates, so are the organisms killed and infection prevented, or the parasitic organisms prevail and make good

their position in the body. In the military service, the privations, hardships and fatigue incident to campaign, and especially the unhealthfulness of localities in which troops may be required to serve, do much to render the organism especially susceptible to invasion by pathogenic bacteria; but unless such bacteria be actually present, even under such conditions no infectious disease can result. Should, however, the specific bacteria be introduced, and should the essential external conditions of heat, moisture and decomposing organic matter be present for their development outside the body, all the conditions for a violent and sudden epidemic outbreak are at hand. These are further favored by the density of population and community of living which can scarcely be avoided in the military service—both of these factors directly favoring the dissemination of pathogenic bacteria among large numbers of men and very probably increasing their virulence.

The principal and original sources of infection in the transmission of infectious disease are the secretions of the sick, the air respired by them, and the dead body. Articles contaminated by contact with the above and harboring the specific pathogenic agent, such as clothing, bedding or the water in which they are washed, are merely mediate carriers of the infection. For the military service, all epidemics may be regarded as developing from an infection introduced from outside. Bearing these facts in mind, the prevention or control of infectious disease will be more readily accomplished by the sanitary officer.

Cerebro-Spinal Meningitis.

Occurrence.—No great epidemics of this disease appear to have occurred among troops, but the affection is one which prevails in all armies and is remarkable for the high mortality given by those affected. Sharp but distinctly localized outbreaks occur annually in all the larger armies, and in our own service cases of the disease were reported in all but six years of the period 1868–98. The affection may fairly be regarded as a camp disease; more deaths occurring in our army in the calendar year 1898 than had occurred altogether in the previous sixteen years of peace. For the period 1868–84, the death rate from this disease was .05 per thousand strength; for the decade 1885–94 it was .02 per thousand, while for the fourteen months, May, 1898, to July, 1899, the death rate was .70 per thousand. In the German army, during time of peace, the admission rates are much lower than our own under similar conditions, being given as follows:

Period.	Admissions per 1,000 strength.
1881–82 to 1885–86	0.03
1886–87 to 1890–91	.07
1891–92 to 1895–96	.08
1895–96 to 1897–98	.07

Among our own troops the admission rates, per thousand strength, were .11 for the period 1885–94. In 1898 cerebro-spinal meningitis was the greatest factor in the total mortality of the Belgian army, giving a death rate of .35 per thousand.

Cause.—The cause of epidemic cerebro-spinal meningitis is now generally regarded as the micrococcus described under the name of diplococcus

intracellularis meningitidis. This organism, as its name implies, is found usually in pairs, and located in the pus-cells of the exudate in much the same way as the gonococcus is located in the pus-cells of gonorrhœa. It is readily detected by microscopical examination of the spinal exudate, obtained by lumbar puncture. The organism can be artificially cultivated, but only with difficulty. It grows best on blood serum or nutrient agar; though occasionally it will not develop in either medium when its presence in the exudate is positively determined by the microscope. It grows only at body temperature. It stains with the ordinary aniline dyes, but is decolorized by Gram's method. It is very virulent when injected into animals. On drying it is destroyed in one to three days, according to circumstances.



FIG. 325.—Diplococcus of Meningitis.

Predisposing Causes.—The disease is most common in individuals of the military age. Though want, privation and poor ventilation usually seem to predispose to the disease, there is abundant evidence to demonstrate that these conditions are not essential to its causation. The disease usually occurs during winter and early spring, although it may make its appearance at any time. For the period from May, 1898, to July, 1899, the death rate from this disease was .13 per thousand strength in January; being about twice as high as any other month of the period. For December it was .07; for June and July, 1898, it was .06 and .05 respectively. Hirsch, Notter and Firth and others state that cerebro-spinal meningitis is unknown in the tropics. During the period of fourteen months just mentioned, however, the death rate from this cause was .71 per thousand strength for troops serving in the United States; .34 for troops serving in Cuba; .16 for those in Porto Rico and .26 for those in the Pacific islands. An epidemic of a most fatal type occured on an army transport at Casilda, in southern Cuba, during the occupation of that island by our forces. Of those attacked, all died within thirty-six hours. The epidemic was abruptly terminated by sending the command ashore. For the year 1899 the admission and death rates for this disease among troops serving in the tropical islands were .40 and .25 respectively; for troops serving in the United States during the same period the admissions were .90 and the deaths .60 per thousand strength.

Infection and Dissemination.—It is difficult to offer any satisfactory explanation as to the manner in which infection occurs in this disease, or to the way in which the specific micro-organism is eliminated from the affected individual. Whether it enters the body through the alimentary or respiratory tract or through lesions of the integument, it is not possible to say. It is probably directly communicable from the sick in a mild degree only, but there is considerable evidence to show that the infection may be introduced into a locality by infected persons and things. Abbott and others are inclined to the belief that cases occurring during an epidemic are infected from some common source, and that they are predisposed to such affection

by some unusual local condition. This opinion is supported by the fact that the disease shows no special tendency to progress along continuous lines or through contiguous localities. It has been known to appear in two regiments in a camp, while a third, located between the infected organizations, escaped. Love states that at New Orleans, in 1847, the disease attacked one regiment, which was quartered in poor barracks located on a damp soil and was supplied with poor clothing, while an adjacent regiment, more favorably housed and clothed, escaped entirely. Depressing influences, whatever their nature, appear to be a predisposing cause.

Prophylaxis.—With present defective knowledge concerning the manner of infection and dissemination of the causative agent in this disease, it is difficult to formulate any rational scheme of prophylaxis against it. While the isolation of the sick has not been shown to be imperative, still this precaution should probably be always taken in the military service. As with typhus and measles, free ventilation should be assured and no considerable aggregation of the sick under one roof should be allowed. As a not unreasonable precaution, all discharges and excreta should be promptly disinfected and accidental inoculation on the part of the attendants guarded against.

As far as the troops are concerned, free ventilation, sufficient clothing, an abundance of good food and the avoidance of excessive fatigue should be included in the scheme of general prophylaxis.

Cholera.

Occurrence.—The military history of Asiatic cholera appears to begin with the year 1757, when the British troops in India suffered greatly from its attacks. It is said that one division of 5,000 men had 500 deaths from cholera in a single day. In 1817, according to Rosse, in a force under Hastings the onset was so sudden that sentries fell as if struck by lightning and it required three or four men to stand a tour of guard duty of two hours; in five days there were 5,000 deaths, and the command was almost destroyed. In 1821, cholera made such ravages in the armies of Turkey and Persia that it forced military operations in Mesopotamia to be brought to an end. In the years 1830–31 cholera extended all over Europe and was shortly afterward brought to this country; troops being attacked at a number of stations. At Fort Dearborn, on the present site of Chicago, it is stated by Rosse that 200 men out of a garrison of 1,000 were admitted to hospital with cholera in the course of seven days. During the Crimean War there were 7,375 cases of cholera in the British army, with 4,513 deaths; in the French army there were 12,258 cases, with 6,013 deaths. Among the French troops composing the Dobrutschka expedition it is said that at one time no less than 10,000 men lay dead or struck down by cholera. Out of one battalion, besides those already dead, 500 soldiers affected with cholera were carried in the wagons. Coustan states that in one division of 10,590 men participating in this expedition there were 2,036 deaths. In 1866, during the war between Austria and Prussia, more deaths occurred from cholera, in the armies of the latter country, than resulted from the casualties of battle. At the close of the Civil War our troops suffered severely from this disease; there being, in 1866, 2,813 cases

and 1,269 deaths. In 1867 there were 504 cases and 230 deaths, and in 1868 there were 7 cases and 3 deaths. Cholera almost destroyed a body of recruits marching from Leavenworth to Fort Hayes, in Kansas, and was also epidemic at Fort Riley and other stations during this period; being carried by recruits from New York to California, Louisiana, Texas and Georgia. In 1866 it also broke out in Brazil and the Argentine and was carried by the armies into Paraguay. In the outbreak of 1873 our army was little affected, there occurring but 12 cases with 8 deaths, and since that year there have been no further deaths from this cause in our service. The French army has suffered with the civil population during the various outbreaks of cholera in France and Algeria. Rosse states that in Paris, for the period 1832–49, and again for 1853, the mortality amounted to 14.76 per thousand among the civil population and 42.59 per thousand among the garrison troops. In many later instances, however, especially in the outbreaks of 1884 and 1893, the greater care as to sanitary conditions in the French military service preserved the soldiers, while deaths occurred in the surrounding civil population. In the British army, during the decade 1888–97, cholera occurred among troops in India, Egypt, China and Ceylon. In India, for this decade, the admission rate per thousand was 1.8; the death rate 1.29. Cholera figures almost annually in the returns for the Russian army, certain military garrisons of which are located in regions where the disease prevails endemically. Recent figures for cholera in the Russian army are as follows:

Year.	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Year.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1890.....	0.06	0.02	1894.....	1.00	0.35
1891.....	——	——	1895.....	.40	.10
1892.....	4.3	1.83	1896.....	.01	.002
1893.....	1.61	.46			

Cause.—Cholera results from an invasion of the body by the specific micro-organism of the disease. The spirillum or comma bacillus is a curved or spiral organism, occurring most frequently in the form of a short, comma-shaped rod. The curving of the rod varies, being very marked in some individuals and absent in others. In cultures some days old, degenerated and atypical forms are found. The organism is motile, and a single flagellum is attached to the end of the rod. The microbe does not form spores nor cause fermentation of glucose or lactose. It liquefies gelatin and produces indol. Litmus milk is turned red and is coagulated by it. It does not stain by Gram's method. Freezing does not destroy its vitality, but drying destroys it in a few hours. When in a moist condition it retains its vitality for many months. Woodhead has pointed out that when grown anaërobically the bacillus gains greatly in virulence but largely loses its power of resistance to germicidal agents; conversely, when grown aërobically, it largely loses its virulence but gains in resisting power. Comma bacilli are only feebly resistant to acid solutions; a fact which explains the greater susceptibility to this disease of individuals affected with digestive disorders. In stab cultures, growth occurs all along the line of inoculation, with liquefaction at the surface in forty-eight hours. The liquefaction proceeds in such a manner that the liquefied area has a smaller

diameter at the surface than immediately beneath, and owing to the fact that the liquefied gelatin does not fill the cavity, a space is left between the surface of the medium and the surface of the liquefied gelatin, so that the appearance of an air-bubble is produced. On gelatin plates the largest colonies, after incubation for twenty-four to forty-eight hours at 20°–22° C., appear as masses of indefinite granular material lying in circular areas of liquefied gelatin, in which granular shreds are scattered. Within the next twenty-four hours the areas of liquefaction increase, and the colonies appear under the low power as a dense granular mass surrounded by an area of liquefaction through which can be seen granular prolongations of the colony, usually extending irregularly between the periphery and the central mass.



FIG. 326.—Bacilli of Asiatic Cholera, showing Flagella. (After Mallory and Wright.)

While in form and methods of growth the comma bacillus is resembled by another group of special organisms, it is safe to assume, during the prevalence of Asiatic cholera, that individuals presenting comma bacilli in their intestinal discharges are affected with this disease. The most important diagnostic tests for this organism depend, according to Muir and Ritchie, upon its failure to infect pigeons when a small portion of a solid culture of it is introduced into the pectoral muscle; and also the loss of motility and clumping of the cholera bacilli which follows upon their contact with the serum of animals artificially immunized to Asiatic cholera. The effect of introducing cholera bacilli into the peritoneal cavity of the guinea-pig is discussed later in connection with the preparation of prophylactic fluids.

Dissemination and Infection.—The specific causative agency in cholera is given off chiefly from the bowels, and to a less degree in the vomitus. The length of time during which the stools of a cholera patient are infectious is unknown, but it probably is a considerable period. As with typhoid fever, apparently healthy persons appear at times, during an epidemic, to act as hosts for the bacilli and play a part in the propagation of the disease. While the disease sometimes follows contact with the sick, it may fairly be regarded as only slightly contagious and not likely to be contracted except by indirect infection. The latter undoubtedly occurs by way of the alimentary tract. There is no proof that air ever serves as the vehicle for the transmission of cholera bacilli; though in this disease, as in typhoid fever, its dissemination by this means should be regarded as possible. Water has long been recognized as the chief agent in the spread of cholera; and abundant circumstantial evidence to this effect is fortified by a number of instances in which the specific etiological factor has been discovered in water by bacteriological investigation. Many instances have been reported in which the infection of a water-supply was followed by outbreaks in communities further down the stream. In the epidemic at Hamburg, in 1892, the part played by an infected

water-supply was most marked; the proportionate number of cases being eight times greater in that part of the city in which unfiltered water was supplied than in the part in which the drinking water was partially purified by sand filtration. Recently, among the British troops at Umballa, in India, an epidemic of cholera promptly ceased as soon as a supply of sterilized water was provided for drinking purposes. Cholera bacilli flourish best in sluggish streams, and especially in water containing a considerable proportion of organic matter. Under certain circumstances, not as yet fully understood, the bacillus is capable of rapid multiplication in water, but many saprophytic micro-organisms are hostile to its development and appear to destroy its vitality in the course of a few hours or days. Any contamination of this specific character, however small, is capable at times of imparting to enormous quantities of water the power of originating the disease. Damp earth undoubtedly serves at times as a medium for the development of the bacillus outside the human body. At Lucknow, 90 soldiers out of 600 died apparently as a result of placing fresh sand, taken from the bank of a river used as a general bathing place, in a filter from which water was drawn for the use of the command. Food, contaminated by cholera discharges, also serves as an agent for the spread of the disease. This is rarely directly infected, but is contaminated by manipulation with unclean hands, by contact with infected objects, by dust containing the specific germs or by the agency of flies which have recently fed on cholera discharges. In India, medical officers now regard the latter as one of the more common agencies by which the spread of cholera is accomplished. In the Burdwan prison, where other means of infection were scarcely possible, it is said by Buchanan that a recent epidemic was directly traceable to flies which were carried over the prison wall by a high wind blowing from the direction of some native houses, in which the disease had occurred. During the outbreak in the Gaya jail, Macrae found that milk to which flies in the jail were given access invariably became infected with comma bacilli; and he concluded that "flies should be looked on in the light of poisonous agencies of the worst kind during cholera epidemics." The cholera bacilli may be carried in fomites, particularly in rags or clothing soiled with the fæcal discharges of the sick. Under such conditions they retain their vitality for considerable periods, though they are readily destroyed by sunlight and desiccation. As with typhoid fever, the disease germs may be carried into camp or barracks on the shoes of individuals who have visited an infected latrine or locality. Marching troops, when infected, do much to spread the disease through districts in which it may have been previously unknown.

The period of incubation of cholera is usually about three days, but this, under rare circumstances, may extend to as much as ten days.

Predisposing Causes.—Cholera prevails endemically in certain parts of India, from which it extends from time to time. It appears to be a settled fact that where the disease prevails in an endemic form it does not occur in great epidemics. A severe outbreak appears to confer upon the locality attacked a more or less complete immunity; the durability of which, so far as India is concerned, appears to last for a number of years. A high temperature is a predisposing cause of great importance; but while many epidemics have ceased with the advent of cold weather, this is by no

means always the case. In the tropics, cholera prevails to the greatest extent toward the close of the dry season. A moderate rainfall tends to cause the further development of the disease, but when the rains are heavy and continued a marked diminution in the occurrence of cholera is constantly observed. There is a general consensus of opinion that the incidence and severity of the disease are greater among negroes than among whites. In the United States army, during the epidemic at the end of 1866, the mortality among the white troops was 77 per thousand, while among the colored troops it was 135 per thousand. Where the disease prevails endemically, the native population appears to enjoy a considerable but not absolute immunity to it. In the Hedjaz and in the sparsely populated parts of Arabia, it is said by Fauvel that the disease manifests only a feeble tendency to propagate itself among the native population. This immunity, however, is not shared by strangers visiting a locality endemically affected. As a race, the Chinese appear to be notably free from the ravages of cholera, probably largely from their use of sterilized water in tea. In any outbreak of this disease, numbers escape attack through their hereditary or gradually acquired powers of resistance. For epidemics of cholera a stratum of moist soil pervious to air, in which organic material is decomposing, affords the most favorable condition. General sanitary defects, by which the specific fouling of soil and water is possible, are essential to the development of an epidemic, and it has long been observed that the poorer quarters of a community suffer far more during a cholera visitation. Epidemics, also, prevail more severely in low-lying regions than on high ground. Insufficient, poor or coarse food, improper clothing and inadequate shelter favor the occurrence of cholera; and physical and mental depression are both markedly predisposing causes. Overcrowding is also a factor of importance. Those who are affected with catarrh of the intestinal tract and diseases of the digestive apparatus are particularly susceptible to cholera infection.

Prophylaxis.—In view of the fact that in practically every instance of an outbreak of cholera, in regions or communities in which it is not endemic, its origin has been traced to importation from abroad, it is manifest that where practicable a system of quarantine should be established as soon as the danger of an introduction of the infection is recognized. No person from the infected locality should be admitted within the military lines without undergoing examination and being held under observation for a period of ten days. All clothing and similar articles should be disinfected before being passed; supplies intended for food, unless carried through the affected district in unbroken packages, should not be admitted. Special cholera hospitals, in readiness for an outbreak, should be established and provided with a special staff of attendants. They should not be located at too great a distance from the main body of troops, from the rapid nature of the disease. Such hospitals should possess separate facilities for the isolation and treatment of suspects as well as clearly defined cases of cholera. If the disease appears to be spreading and the camp or post is not in good sanitary condition, its abandonment by troops is indicated.

When the disease prevails, all persons suffering from diarrhœa, no matter how insignificant the affection may appear, should be regarded as suspicious and should be subjected to the same vigilant supervision as applies to genuine cholera patients—for many of these cases, though mild as regards

the affected individuals, are nevertheless those of true cholera and are capable of disseminating this disease. Because of their apparently innocent nature these cases often escape the attention their importance demands; and unless it be borne in mind that they are a grave menace to all with whom they are associated, and are treated as such, they can only be regarded as most dangerous sources for the dissemination of disease—far more so than the severe cases which attract attention from the outset. To this end, frequent inspections of latrines should be made and the character of the discharges noted. Convalescents from cholera should be kept isolated, and the evacuations from the bowels should be constantly disinfected until bacteriological examination demonstrates that the specific micro-organism causing the disease has disappeared from the discharges. Such individuals should be returned to their respective organizations only after a disinfecting bath and after donning a complete outfit of clothing sterilized throughout. The antecedents of each case of cholera should be investigated, and all those who have been in immediate association with the patient should be placed under observation. Every effort should be taken to locate the probable source of infection.

As cholera germs can live and multiply for a time, outside the body, in the presence of decomposing organic material, more particularly that of animal matter, there should be a thorough removal of every sort of filth and refuse from the camp or garrison. Thorough cleansing, airing, painting and lime-washing should be carried out wherever indicated. It should not be forgotten that, although desirable at all times, measures of cleanliness taken in advance are of far more value for protection against cholera than policing delayed until after the disease has actually made its appearance. The water used for drinking purposes should invariably be sterilized; preferably by heat and best by the Forbes-Waterhouse apparatus. Under all circumstances, in time of cholera, an immediate and searching examination of the sources and conduits of the water-supply should be made, when it is in any way open to the suspicion of impurity. Where pollution is found to have occurred, every care should be taken to prevent such pollution from continuing and the water from being utilized. Where the water supply is believed to be at fault, washing of the person, except with boiled water, should be prevented as far as possible. For marching troops, great care should be taken to prevent the use of water from infected towns. Tea has been much used by British troops in India during cholera outbreaks, as being more palatable than ordinary boiled water. Acidulated drinks containing sulphuric acid, acetic or citric acid may sometimes be given with advantage. Red wine is also recognized as destructive to the cholera bacillus; and a ration of this, taken diluted in water, might well be issued during an epidemic. The use of alcoholics generally, as interfering with digestion, should be avoided. The food supplied should be abundant, simply prepared and readily digestible. Intemperance in eating, however, is quite as bad as intemperance in drinking. Particular care should be taken to ensure the condemnation and rejection of any food of unsound or indigestible character capable of exciting a diarrhœa. With the exception of acid fruits protected by an outer rind, such as oranges and lemons, no article of food should be eaten that has not been subjected to a boiling temperature in its preparation. Under no circumstances should the use of uncooked vegetables or

salads be permitted. All food and drink should be carefully protected against access by flies, since some of these may have previously come in contact with cholera discharges. Prior to use, all vessels employed for the cooking, serving or storing of food should be sterilized by immersion in boiling water. The purchase of food or drink by the men at points outside of military control should be prohibited. The hands should be washed before eating. Troops should be well clothed, sufficiently to protect against cold, chilling and moisture; it is during outbreaks of intestinal disorders of this character that the use of the abdominal band is of most advantage. The clothing should be frequently changed, washed and sunned.

There should be no unnecessary exposure to sun, rain or night air; and no drills or fatigue other than to furnish occupation and needful exercise. The size of the guard and the length of the tours of duty should be reduced as much as military conditions permit. In addition to fatigue, nothing is more conducive to the spread of the disease than fear and unusual excitement, and a quiescent state of mind should be enjoined upon all. In general, the troops should be regarded as engaged in campaign against an insidious and implacable enemy, and the attention of every officer should be devoted to superintending the conduct of his subordinates with special reference to this view.

In time of impending epidemic, troops should be scattered. A change of soil and locality often appears to be of advantage and camps should be moved as often as cases appear. Troops that have fallen back before the advance of the disease have often escaped seizure, or have avoided further sickness if withdrawn subsequent to the time of their attack. A temporary abandonment of an infected locality is strongly to be recommended. When the disease has actually occurred, efforts at disinfection should be primarily directed toward the vomitus and fæcal matter. These should, as far as possible, be burned. If the cases occur on board ship, the excreta should be received in vessels and disinfected. They should not be discharged overboard, particularly if in harbor or on fresh water, but should be destroyed by fire. The disinfection to be practiced includes that of the barracks, tents or places occupied by the sick, and the articles of clothing and bedding with which they may have come in contact—and upon its promptness and thoroughness, together with isolation of all those attacked by cholera and their attendants, depends the arrest of the epidemic. If due care in regard to cleanliness and disinfection be observed, there is comparatively small risk that the disease will spread to those who nurse or otherwise attend upon the sick. Frequent baths on the part of the attendants, with disinfection of the hands after each manipulation of the patient, should be required.

Preventive Inoculation.—As a method of prophylaxis against cholera, inoculations with specially prepared virus have been systematized and successfully practiced in India by Haffkine. The method gives an immunity to the living microbe, preventing it from surviving after entering the system and thus causing an attack of the disease. If, however, the specific bacillus once succeeds in establishing itself, the inoculation appears to have no influence upon the symptoms of the disease, as produced by the toxines resulting from its growth and development. The method depends upon the immunizing of the patient by accustoming the system of the individual to the

specific organism by the injection, first, of a weak, and later, of a virulent culture. By some, small and large doses of a virulent culture are preferred.

As the cholera bacilli found in dead cholera cases vary greatly in appearance and virulence, Haffkine advises that only the most typical specimens be employed in the preparation of the prophylactic fluid. This is done as follows: A pure culture, grown on agar, is emulsified with a small amount of sterilized water. The emulsion is then drawn into a suitable pipette and injected into the peritoneal cavity of a guinea-pig, previously prepared by an assistant by shaving and searing the abdomen. The animal usually dies in twenty-four to forty-eight hours after the inoculation, and the peritoneal exudate is found to contain comma bacilli of greatly increased virulence. This exudate is then passed into the peritoneal cavity of another guinea-pig, and the process is repeated until the microbe reaches its maximum virulence, when a healthy guinea-pig, weighing about 375 gm., will be killed in about eight hours. Between each inoculation into the guinea-pigs, the exudate should be stored in a dark place for fourteen to sixteen hours, since if this be not done the microbes soon lose their virulence and die out. The exudation, where the bacilli are vigorous, is clear and transparent and of a reddish color. It varies greatly in quantity, ranging from six or seven cubic centimeters to a few drops. In general, the larger and more resistant the guinea-pig inoculated, or the weaker the virus or the smaller the injected dose, the larger will be the quantity of the fluid—and vice versa. Large quantities of exudate contain proportionally few microbes.

Agar tubes inoculated with virulent peritoneal exudate are now incubated for twelve to twenty-four hours at 37° C. A free growth is obtained by passing the point of a small glass brush, carrying a growth obtained from a culture of the peritoneal exudate, over the agar slant until the surface is evenly infected. After incubation and an examination to ensure that no contamination by other micro-organisms has occurred, sterilized water is poured into each tube. Usually, for growths made in twenty-four hours, the water should reach one-third the way up the agar slant. The tube is then rolled between the fingers until the bacilli have been soaked off into the water. The emulsions should be protected against sunlight, or a strong diffuse light, and should be used within an hour. The inoculation is made under antiseptic precautions, usually in the flank. Hare makes the following remarks as to the dose: "A standard bacteriological tube is 16 cm. long and $1\frac{1}{2}$ cm. broad, and is filled to two-thirds of its height with agar mixture. Such tubes, with a culture of comma bacilli of the full strength after twenty-four hours' growth at the temperature of the body, may be taken as a unit; and when filled with water up to one-third the height of the agar, each tube will give a definite quantity of vaccine of a standard strength. The dose of such vaccine for an adult is half a cubic centimeter. To decide the dose of the second injection the operator must rely exclusively on the amount of fever produced by the first. The average height to which it rises after a full dose is 102°–103° F., ten to twelve hours after the operation; in such cases a full dose of the second vaccine may be given; but in exceptional cases where the fever reaches 104° F., or over, give only two-thirds of the full dose, and when the fever stops below 101° F., give in excess of the full dose."

In some instances the bacilli are killed before injection by the addition of dilute carbolic acid, but living microbes are ordinarily employed. According to Cantlie, the bacilli die immediately after the fluid is injected subcutaneously, and hence the choice of either form seems immaterial. Other observers believe that the immunity conferred by living organisms is of longer duration than where the dead bacilli, or the products of their cultures, are employed. The method of inoculation, when proper care is taken in the preparation of the anti-microbic fluid and in its administration, appears to be quite devoid of danger. In speaking of the reaction which follows such inoculation, Simpson says: "There is a certain discomfort produced by the inoculation, such as an attack of fever lasting about twenty-four hours, pain at the seat of inoculation on moving, thus interfering with physical work for about thirty-six hours. The discomfort, however, is not worse than that induced by vaccination, when the vesicles have risen well, and has the advantage of not lasting nearly as long."

The protection conferred seems to be marked at the end of four days, and during this period the difference in susceptibility to cholera is in favor of the inoculated. The duration of the immunity acquired has been shown to exist for at least fourteen months. Simpson states that the blood sera of individuals after inoculation have a destructive effect on cholera bacilli which is more than two hundred times greater than that of the sera of unprotected persons.

A large number of individuals—upward of 100,000—have been inoculated by Haffkine, in India, against cholera; among them a number of white and native soldiers in the British service. While the results have varied greatly, they are on the whole distinctly favorable. Among 1,526 non-inoculated soldiers at Dinapore and Cawnpore there were 25 cases, while among the 268 inoculated there were no cases. In Calcutta, from the 10th to the 459th day after inoculation, cholera visited 26 houses. Among the 263 uninoculated inmates there were 14.45 per cent. attacked, while among the 137 inoculated the proportion attacked was only .75 per cent. The East Lancashire regiment received weak protective inoculations. Some months later it was exposed to cholera, and the small death rate showed the prophylactic value of the inoculation. According to Simpson, 654 individuals not protected against cholera had, during a period of two years, a mortality of 10.86 per cent.; while of 402 members of the same households, inoculated by him, the mortality from cholera during the same period was but 2.99 per cent. While prophylactic inoculation against cholera is still under trial, it may fairly be assumed that a means of prevention of much value has been discovered.

Dengue.

While dengue is not a disease which appears to be in any way affected by the conditions of military service, our troops have suffered equally with the surrounding civil population during the epidemics which have from time to time occurred. Since this affection is confined to tropical and sub-tropical countries, the only posts in this country which have been visited are those located in the south and southwest. During 1893 the affection prevailed in several garrisons. In 1894 the disease occurred at

Fort Ringgold, attacking 154 men out of the 178 stationed at that post. In 1897 dengue appeared at Fort Sam Houston; 144 cases developing out of a total strength of 522, and over 100 cases being treated among the families of soldiers and civilians at the post. During the same year the garrison at Fort McIntosh also suffered. Recently a large number of cases of this disease have occurred among our troops in Cuba and in the Philippine Islands.

The cause of dengue is unknown. The outbreak of the disease is favored by high temperature and geographical location more than any other factors; occurring chiefly during summer and early autumn and being checked by frost. In its distribution, dengue closely resembles yellow fever. Overcrowding and filth appear to favor its occurrence. The mortality is small, and for soldiers otherwise in good health may be regarded as *nil*. The disease, therefore, is of importance only as it incapacitates for duty. The specific cause of the disease is supposed to be given off in the saliva and excretions, and perhaps from the skin. Its incubation period is only a few hours, a fact which may explain its almost simultaneous appearance in large bodies of men.

Prophylaxis.—In the lack of knowledge as to the cause of this disease or the means of spreading it, it is not possible to formulate definite plans for its prevention. Since the ubiquity of the virus is so great in this disease, the establishment of quarantine would scarcely be effective even if it were justifiable. The isolation of the sick, with the disinfection of all excreta, clothing and surroundings, might be practiced, but would probably not be of any great value in checking an epidemic. It is fortunate that the disease is mild in type, is of short duration and leaves no after-effects—thus being of comparatively little importance to the military sanitarian.

Diarrhœa and Diarrhœal Disease.

Diarrhœa is ordinarily to be regarded not as an essential disease but as symptomatic of some morbid internal condition or of an effort on the part of the healthy bowel to relieve itself of irritating contents. In the military service, however, the affection frequently prevails among a large number of soldiers at the same time and place, and by its severity, its tendency to become chronic, its refractability to treatment and its undoubtedly infectious character it may, under such conditions, be safely regarded as a distinct disease. Figures showing the prevalence of this specific affection are not available for our service, owing to the classification of all diarrhœas, whether symptomatic or essential, under the same heading. Further, in the medical reports of our army, conditions of this character, together with dysentery, are classed together as diarrhœal disease and hence must be largely considered in relation to each other.

Diarrhœal diseases produce a large amount of inefficiency and during the decade 1887–96 brought more men on sick report than any other class of affections, the rate per thousand strength being 107.09. Field service largely favors their occurrence, and in nearly all wars they have been the most common class of affections occurring among troops. For the year of peace 1897, the admission rate in our army for all diarrhœal diseases was 73.77 and the death rate zero; while during the year of war, 1898, the admission

rate was 303.76 and the death rate 2.14. These diseases are much more prevalent in hot climates than in the temperate zone, the admissions and deaths for troops in the United States alone, during the year 1898, being respectively 247.39 and 1.39 per thousand strength; while for those serving in the tropical islands the admissions were 551.54 per thousand, and the deaths 5.44.

For diarrhœa alone, the average annual rate of admission was 608.84, per thousand strength, during the Civil War; while the deaths from this cause averaged 13.70 per thousand. For the period 1868–84 the admissions for diarrhœa were reduced to 230.45, and the deaths to .26, per thousand strength. For the decade 1885–94 the admission rate was 109.65 and the death rate .02. For the year 1897 the admissions per thousand amounted to but 68.65, there being no deaths. For the year

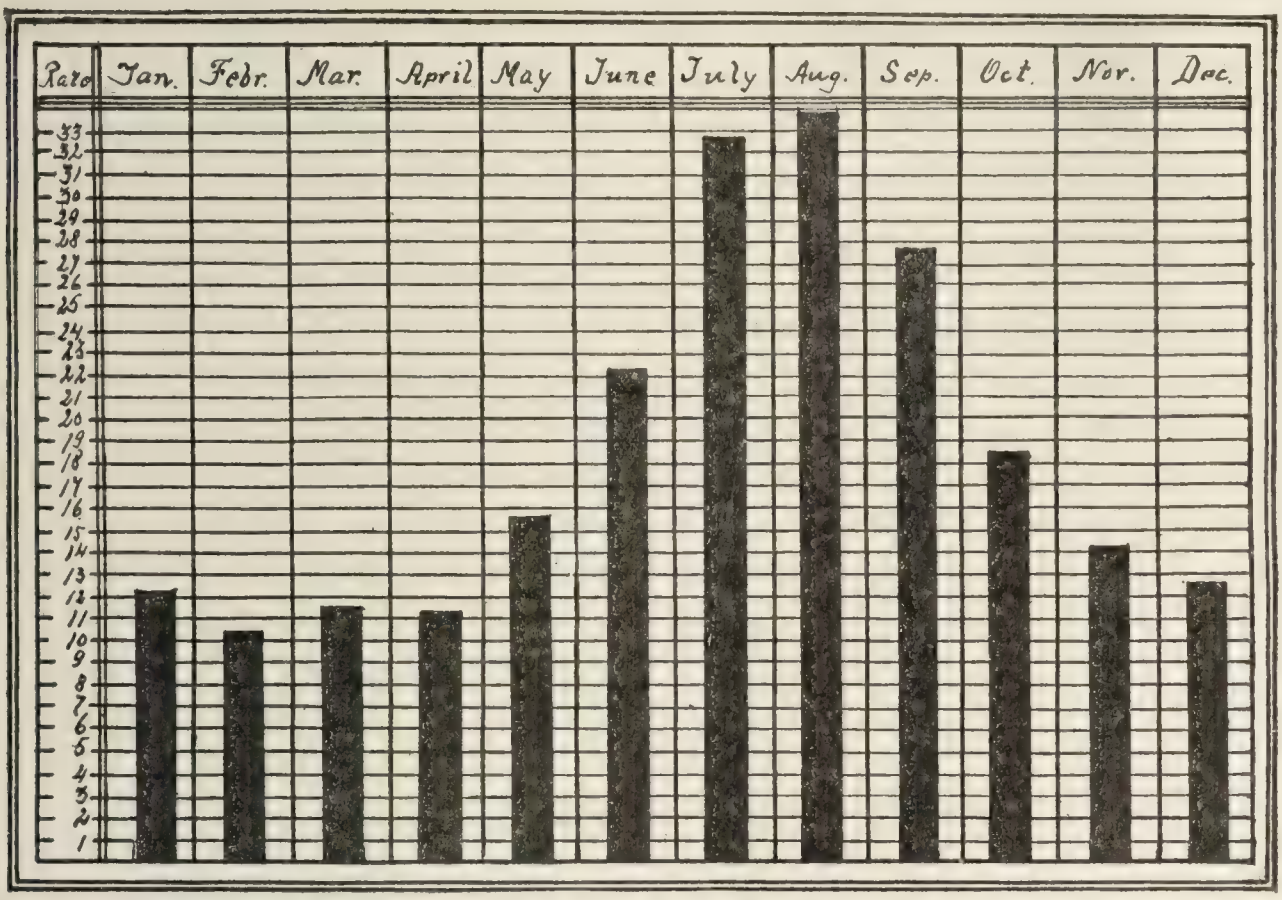


FIG. 327.—Chart Showing the Monthly Distribution of Cases of Diarrhœal Disease, per Thousand Strength, Occurring during the Decade 1875–84, in the United States Army.

1898, during the war with Spain, the admission rate rose to 274.49, but the death rate amounted to only .27 per thousand strength.

Diarrhœal diseases, in the temperate zone, are much more prevalent during hot weather, as is well shown by the accompanying diagram. Race is a matter of no small importance. While the colored troops are particularly susceptible to infection by dysentery, this is not the case with regard to simple diarrhœa, to which they appear to present a certain immunity. For the decade of peace 1886–95, the admissions per thousand of white troops, for all diarrhœal diseases, amounted to 115.68; while for the colored troops during the same period the rate was 99.75. For the year 1897 the rates of admission were 75.78 for white troops and 52.22 for colored soldiers. During the war with Spain a proportionally much greater number of negro soldiers saw hard service than did those of the white regiments, yet the admissions for the former were only 187.20 per thousand strength, while they amounted to 312.72 per thousand of the latter. Age

exerts a marked influence on the occurrence of diarrhœal diseases; the rates for our service, at various periods of life, averaged for the seven years 1890–96, being as follows:

Age.	Admissions per 1,000 of each class.
19 years and under	202.43
20 to 24 inclusive	134.19
25 to 29 "	98.70
30 to 34 "	82.00
35 to 39 "	79.00
40 to 44 "	80.96
45 to 49 "	75.68

For the same seven-year period the admission rates for all diarrhœal diseases, per thousand strength, were thus divided among various branches of the service:

Artillery	133.35
Cavalry	113.29
Infantry	96.84
Medical Department	34.96

Diarrhœal diseases are much less frequent among officers than among soldiers.

As stated above, in many instances diarrhœa is undoubtedly infectious and capable of transmission to others by means of the excreta. No special micro-organism has been shown to stand alone in a causative relationship to the disease, and the latter may probably be produced by several forms of bacterial life. Diarrhœa prevails most in damp soils, especially when contaminated with organic matter. The diarrhœa prevalence and death rate are notoriously greatest among those whose resistive powers are impaired by malnutrition, exposure and fatigue. As with dysentery, chilling and sudden changes of temperature appear as predisposing factors. Foul air favors it, and want of ventilation and light are conducive to a high mortality. Density of population, especially as a factor in the soil pollution of camps, markedly increases the prevalence of diarrhœa. Food is closely concerned with the epidemic prevalence of diarrhœa; not only by predisposing toward it through the production of digestive disorders, but also by its contamination with infectious material capable of directly provoking the disease. Bad water undoubtedly plays a prominent part, but probably not to the extent supposed by some. The cause of epidemic diarrhœa is undoubtedly transmissible by means of flies, and there is considerable evidence to show that air-currents may be the means of its dissemination.

A distinction should be made between the epidemic diarrhœa indicated by the foregoing and those outbreaks of diarrhœa which not rarely occur among troops who have partaken of food in which certain putrefactive changes have occurred. In these cases the causative agent is usually a chemical substance and the diarrhœal symptoms produced are merely those due to the properties of the latter as an irritant poison.

Prophylaxis.—The prevention of epidemic diarrhœa depends upon the proper location of the camp, the absence of organic pollution of the soil, a pure water supply, the careful selection, preparation and storage of food, and the prompt disinfection of all excretal discharges in camps of any permanency.

While mild cases, in garrison, may be safely treated in quarters

under most circumstances, in the field, where their infectious nature is suspected, such cases should preferably be removed to hospital for treatment—particularly since cases of apparent simple diarrhœa may often represent the early stages of infection with dysentery, typhoid fever or cholera. From the many causes by which diarrhœa may be produced, it is evident that no general rules of prophylaxis can be laid down to cover all contingencies, but each instance must be acted on independently, according to its merits, by medical officers.

Diphtheria.

Occurrence.—Diphtheria is a disease which is of somewhat rare occurrence among soldiers. It is less common during active field service than in garrison, where it not rarely retains a foothold in old badly constructed barracks for long periods, yearly outbreaks occurring during cold weather. The disease is relatively frequent among troops living in casemates. At Fort Yates it occurred annually for a number of years, despite every effort toward its prevention, among soldiers quartered in old decayed log barracks; while troops living in barracks of recent and more sanitary construction at the same post were scarcely affected. This tenacity of the diphtheria infection, in old buildings or those with defective plumbing, has often been noted.

Figures for this disease show a somewhat lessened prevalence in our army as compared with those of England, France and Russia. In the German army the admissions for diphtheria, per thousand strength, have been as follows:

Period.	Admissions.
1881–82 to 1885–86	1.2
1886–87 to 1890–91	.92
1891–92 to 1895–96	.93
Year 1896–97	.57

In the Austrian army, for the year 1897, only one case occurred for each ten thousand men. For our own service, statistics would seem to show that the disease has of late years decreased in both frequency and virulence. Whether this is actually the case, or whether the reduction merely depends upon more accurate modern methods of diagnosis and treatment, is a question which cannot be definitely decided—but it is probable that both factors should be taken into consideration. During recent years, however, according to Coustan and Viry, the disease has steadily increased in the French army. In our own service the admissions for diphtheria since 1860, per thousand strength, have been as follows:

Period.	Admissions.
1861–66 (Civil War)	3.39
1868–84	.55
1885–94	.43
1895–98	.78
Year 1897	.43
Year 1898 (Spanish War)	.36

Cause.—Diphtheria is caused by a specific micro-organism, the bacillus diphtheriæ. In morphology, the bacillus varies greatly according to the method of its growth. In diphtheritic membrane the bacilli appear as

slender rods, straight or slightly curved. Sometimes the ends are swollen or clubbed, but often they are rather tapered off. There is want of uniformity in the bacilli when compared side by side; and they also stain irregularly, giving a dotted or beaded appearance. They do not form spores or liquefy gelatin, and are not motile. The bacillus grows readily in most of the ordinary nutrient media, especially those of feebly alkaline reaction that can be kept at body temperature. On blood serum, colonies appear within twenty-four hours, often before any other growths are visible. In cultures, the bacilli possess great vitality. At 37° C. they may survive for two months, and at room temperatures even longer. In the moist condition they are readily killed at 60° C. in a few minutes; but when dried they can resist a temperature of 98° C. for one hour. In the presence of light or moisture, the bacilli exposed to room temperature die out somewhat more rapidly, and in cultures they are destroyed by direct sunlight in one-half to three-quarters of an hour.

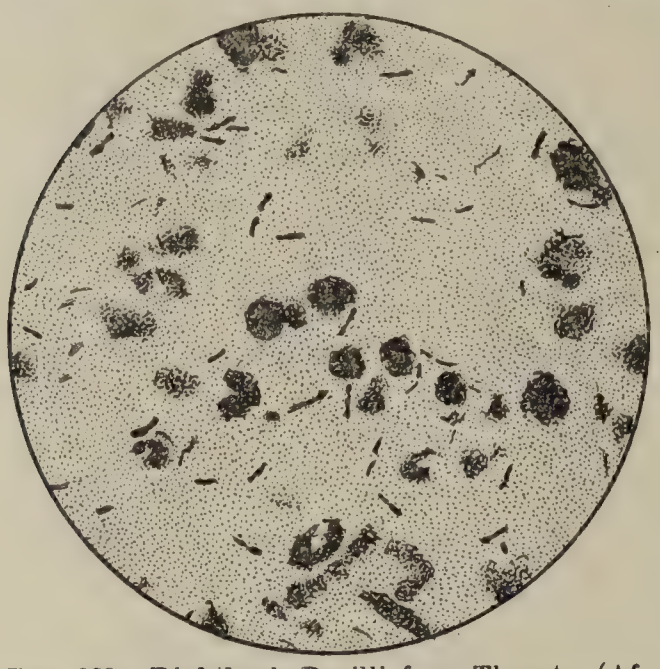


FIG. 328.—Diphtheria Bacilli from Throat. (After Muir and Ritchie.)

Dissemination and Infection.—The causative agent of the disease is transmitted from the sick in the discharges and secretions of the affected surfaces. In diphtheria affecting the throat and fauces, the disease is transmitted chiefly through the infected particles of mucus or flecks of membrane which may be ejected from the mouth or nose by the act of coughing or sneezing. When the disease occurs among those in attendence on the sick, its origination is usually brought about by infection in this manner. It has already been noted that the bacillus of diphtheria is very resistant to drying, and when dislodged from the throat in bits of false membrane it may retain its vitality for a long time. When such particles of membrane are dried and reduced to dust, infection may occur from the inhalation of air in which such particulate matter is temporarily suspended. All clothing and other articles which have been in contact with the sick and upon which saliva has been allowed to dry may serve in this way to spread the infection. Abbott states that diphtheria bacilli have been found in the hair and on the shoes of nurses in a diphtheria ward—also on brooms used in the same ward. The bacilli may be inadvertently conveyed to the mouth after handling infected articles; and, in fact, any direct or mediate contact with the sick offers opportunities for infection. There is no evidence that the disease is ever transmitted by water. Milk, specifically infected during handling, has been known to give rise to diphtheria. Among the lower animals, cats may be affected with this disease. While the specific bacilli are capable of development on any mucous or abraded surface, for military purposes infection may be considered to occur through the mouth and nose only. The period of incubation is difficult to determine; symptoms of invasion often appear within thirty-six hours after infection, but though they are rarely delayed more than four or five days they may be absent longer, and a quarantine of suspected cases for ten

days is advisable. Convalescents from diphtheria should be regarded as sources of infection so long as the specific bacilli can be detected in the throat or secretions. The duration of infectivity appears to be, on an average, about thirty days, though it may be as long as three or four months.

Predisposing Causes.—Though widely diffused, diphtheria prevails chiefly in temperate and cold, damp climates. Low-lying districts, possessing a soil retentive of moisture and rich in decaying organic matter, usually show a greater prevalence from diphtheria, especially if subject to the continued prevalence of cold winds with a high rainfall. In our service the disease is far less frequent in the southern garrisons. Its greatest incidence occurs in winter and early spring, probably largely through less free ventilation of barracks and the depressing influence of a vitiated atmosphere. The part long thought to be directly played by sewer gas in the production of diphtheria was undoubtedly due to accompanying influences of the above nature. Overcrowding is a factor of great importance in the spread of the disease, as is also inadequate sanitary police. Epidemic diphtheria, according to Klebs and others, has a well-defined relation to manure and compost heaps, in which the germs find favorable conditions for development. From this it would seem that the disease should occur more frequently among mounted troops, and such in fact is actually the case. While statistics for our own service are scarcely large enough for reliable comparison, it has been found by Longuet that in the French army, for the period 1872–85, the relative proportion of diphtheria among cavalry and infantry was in the ratio of 10 to 3. In the German army, 1874–82, diphtheria was more than three times as common among cavalry as among infantry. In general, persons who have been affected with diphtheria are especially liable to future attacks, as are those who suffer from acute or chronic inflammations of the pharynx or tonsils. For our own service, it would appear that the colored troops are less susceptible to the diphtheritic infection.

Prophylaxis.—In the prevention of diphtheria the provision of dry, sunny, well-aired barracks, free from overcrowding, is important. No accumulation of filth or refuse, and particularly stable manure, should be permitted in the vicinity. Dampness arising from the use of too much water in cleansing floors should be avoided, as often producing a pharyngeal or tonsillar inflammation upon which a diphtheritic infection may be engrafted. Laveran regards the general use of antiseptic mouth washes as of advantage during the prevalence of the disease. Where the disease has actually occurred, the sick should be at once isolated and all clothing, bedding and other articles which have been exposed to infection promptly removed and disinfected. The squad-room in which the affected individual was quartered should be disinfected. All discharges from the point of diphtheritic invasion should be received into a strong germicidal solution; or on cloths, which are then burned. Soiled bed or body linen should be at once removed and disinfected before the secretions or discharges dry upon them. Where this is not practicable, the soiled areas may be wet with some strong disinfectant solution. The floor should be frequently mopped with a similar solution; and the hanging of a damp sheet over the door leading into the isolation room is of advantage. Eating utensils should be scalded

after use and all uneaten remnants of food at once burned. On the part of the attendants, great care should be taken to disinfect the hands after each manipulation of the patient. While attending to the sick, a cotton mask, suspended so as to shield the nose and mouth and moistened with some antiseptic solution, may be worn to prevent possible infection from ejected mucus or membrane. Careful disinfection of the room and its contents is, of course, required after removal of the patient.

Protective Inoculation.—In preventing the occurrence of diphtheria in those exposed to infection, the most important prophylactic measure is that through which a condition of insusceptibility is conferred by the subcutaneous injection of blood-serum from an animal rendered highly immune to this disease. As the immunity thus produced is not permanent, lasting but four to six weeks, the procedure should be employed only in soldiers who have been presumably exposed to infection, or for the protection of such Hospital Corps men as are about to assume charge of diphtheria patients.

The method of preparing this protective serum is as follows: Very wide, flat, loosely-stoppered flasks, containing bouillon in a layer of small depth, are inoculated with virulent diphtheria bacilli and incubated at 37° C. for about three or four weeks. In order to obtain an active toxin it is desirable that the bacillary growth should take place in the form of a dense white pellicle on the surface of the bouillon. The bacilli are thus brought in contact with a free supply of oxygen, which is necessary for the best results; and it is important to keep the flask undisturbed after the pellicle has begun to form, in order to avoid breaking up the film of bacilli. The latter are then destroyed by the addition of sufficient tricresol to make a strength of one per cent. and the solution is allowed to stand for several days; the toxin solution appearing to gain in strength from the substances dissolved out of the dead bodies of the bacilli. The latter are then removed by filtration through porcelain. Before using the toxin it is standardized, so that the solution of toxin, when injected in the quantity of .01 c.c. into a guinea-pig of 300 gm. weight, will produce death in twenty-four to thirty-six hours. A young, healthy, well-nourished horse, which has been previously tested for glanders and tuberculosis with mallein and tuberculin, and which has been given careful attention in the matter of food, water and sanitary surroundings, is then given a subcutaneous injection of 1 c.c. of the standardized toxin solution. Following the injection of the toxin there are irritability and elevation of temperature, lasting about three days. After a few days of normal temperature a second and somewhat larger dose is given, and the process is repeated with rapidly increasing doses until in from ten to twelve weeks the animal is receiving an injection of 300 c.c. of the toxin solution with impunity. A small amount of blood is then withdrawn and the serum tested as to the amount of antitoxin it may contain. This is done by simultaneously injecting a guinea-pig with .1 c.c. of standardized toxin (ten times the fatal dose or "toxic unit") and a given quantity of the serum under trial. The minimum quantity of the specimen serum which will prevent a lethal result under these conditions is said to contain an "antitoxic unit." If the serum does not come up to a certain strength of antitoxic power, the horse is subjected to the injection of toxin for a further period, and after a time the trial is repeated. When the antitoxic strength becomes satisfactory, the blood is drawn through a

cannula passed into the jugular vein and is received into large flasks capable of holding about 1.5 liters. When filled, these flasks are transferred to an ice-safe or cooling room, where they remain for about twenty-four to thirty-six hours, sheltered from light, until complete coagulation has taken place. The serum is then drawn off by pipettes. About 8 liters of horse's blood will, as a rule, yield about 3.5 liters of clear serum. After determining the antitoxic strength of the serum, a small amount of carbolic acid or tricresol is added as a preservative and the fluid placed in sterile bottles; the label thereon stating the amount of serum, number of antitoxic units and date of production.

The antitoxic strength of the serum appears to vary according to the animal from which it is produced. Sera for commercial purposes vary greatly in potency and their strength is often over-rated. In serum-therapy, as in other classes of medication, an absolute knowledge of the doses employed is of the first importance. In general, for military use, the serum should be so standardized as to contain 100 antitoxic units per cubic centimeter. To produce more concentrated sera requires greater care, a longer period of inoculation and smaller and less frequent bleedings.

For immunization of those exposed to the infection of diphtheria, an injection of serum containing 400 to 500 antitoxic units is sufficient.

Dysentery.

Occurrence.—Of all the diseases to which troops are subject on active service, especially in hot climates, dysentery is one of the most formidable and important; and this almost equally on account of its frequency, its severity, the difficulty of its treatment and its proportionately high mortality. The disease is one which is peculiarly favored by camp life.

History gives many instances in which dysentery has prevailed epidemically among troops. It made frightful ravages in the army of Xerxes, in 480 B.C.; and it is recorded that in the invasion of Italy by Theodebert in the year 538, one-third of his force died of this disease, compelling a retreat. The army of Henry IV. was reduced three-fourths of its effective strength before the battle of Agincourt through an epidemic of this disease. In 1773, half the English army at Hanau had dysentery, which decreased on the abandonment of the camp; and the same occurred in 1778 in the army of Prince William of Hesse. In 1787, the French army introduced an epidemic of this disease among the civil population of Mayence. In 1793 it ravaged the French army in Italy, and in 1812 in Poland. In Egypt, Napoleon lost more men from dysentery than from the plague which occurred at the same time. It prevailed largely during the Crimean War; and Laveran states that in three months there were treated, in the hospitals at Constantinople, 9,919 cases of diarrhœal disease—chiefly dysentery, of which 15 per cent. proved fatal. Before Metz, in 1870, it was one of the greatest causes of mortality in the besieged army. In the military operations in our own country, it prevailed in the French War of 1756, while during the Revolution it became epidemic in the trenches before Boston. It was most extensive and fatal during the Seminole War in 1836; and the same was the case during the war with Mexico. During the Civil War period, July, 1861, to June 30th, 1866, the average rate of admissions

for dysentery, per thousand strength, was 120.88; the death rate for the same cause and period was 3.67. While the admission rate varied but little during these years, the mortality steadily increased; the death rate per thousand strength for this cause being 1.64 in 1861–62 and 6.31 in 1865–66. Since the Civil War, the frequency of its occurrence in our service is shown by the following figures:

Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1868–84.....	29.04	0.59	1868–98.....	19.91	0.45
1885–94.....	6.52	.10	Year 1897.....	2.39	——
1895–96.....	12.05	.68	Year 1898.....	28.09	1.86

The rates for dysentery in foreign armies during time of peace, like those until recently obtaining in our own service, are low. Among the British troops stationed in the United Kingdom during the decade 1888–97, the admissions per thousand strength amounted to .5, the deaths to .2. For the year 1898 the admissions amounted to .7 and the deaths to .03. The occurrence of dysentery in the German army is shown by the following rates:

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1881–82 to 1885–86.....	1.4	Year 1894–95.....	0.25
1886–87 to 1890–91.....	.24	Year 1895–96.....	.57
1891–92 to 1895–96.....	.31	Year 1896–97.....	.10

The milder cases are not taken into hospital in the German army and do not figure in the above rates.

In the Austrian and Russian armies the rates of admission, per thousand strength, have been as follows:

Year.	Austrian army.	Russian army.	Year.	Austrian army.	Russian army.
1892.....	4.1	3.4	1895.....	1.2	2.3
1893.....	1.3	2.1	1896.....	.8	1.6
1894.....	1.3	2	1897.....	.6	1.7

The case mortality in the Russian and Austrian armies during the above period was twice as high as in our own military service or in those of England and Germany.

No single point more clearly shows the value of modern military hygiene and sanitation than the great and progressive reduction of the rates for dysentery which has occurred in all armies in the last two score years. Not only has the proportion of admissions been largely decreased but the case mortality has been reduced to an even greater degree. For our own army the improvement—as well as the favoring influence of field service on the occurrence of this disease—is well shown in the accompanying chart; for the French army in Algeria it is stated by Coustan that, in 1847–48, out of every 1,000 deaths from all causes, 403 were from diarrhœa and dysentery, chiefly the latter, while for the period 1867–78 this disease occasioned but 72 deaths out of each 1,000—and the rate has fallen progressively since that time.

Cause.—The dysenteric condition, as far as present knowledge goes, appears to be due to several different exciting causes. First, a tropical form

directly due to an amœba; second, various diphtheritic and catarrhal forms without amœbæ, apparently produced by bacteria of different kinds, but

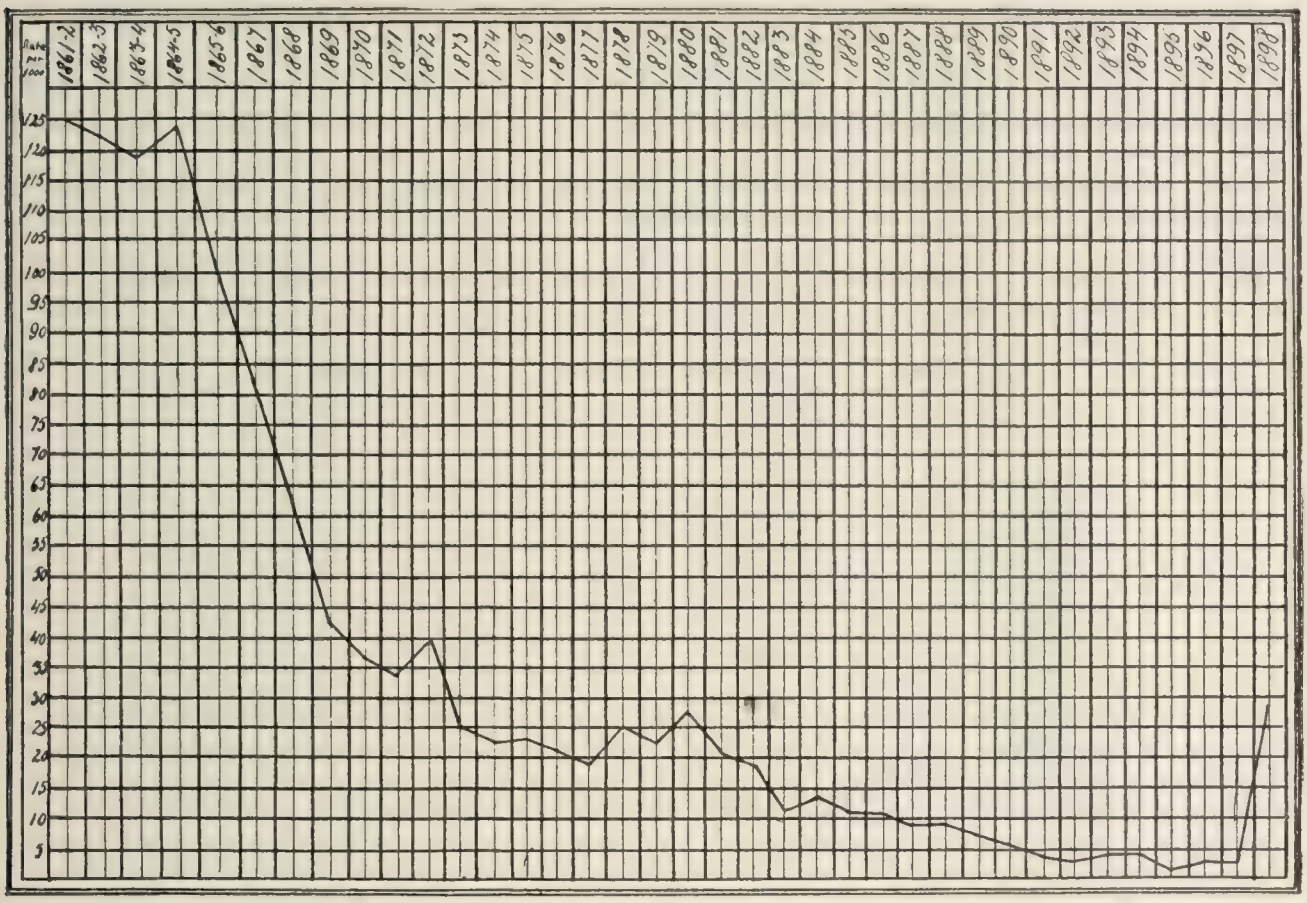


FIG. 329.—Admissions for Dysentery in the United States Army, per Thousand Strength, for the Period 1861–98, Excluding the Year 1867.

the nature of which has not been fully investigated. This form is rarely fatal. Third, the Japanese form of dysentery as first investigated by Ogata. In many instances there appears to be an infection of dysentery engrafted on a previously existing diarrhœa, and this is nowhere more frequently observed than among troops during field service. On the other hand, it is probable that the specific cause of dysentery is often introduced into the system without giving rise to the disease; it being only when the resistive powers of the mucous membrane are impaired by other causes that it becomes vulnerable to attack.



FIG. 330.—Amœbæ of Dysentery. *a* and *b* show amœbæ as seen in fresh stools; *c* shows an amœba in fixed film preparation. (After Muir and Ritchie.)

The amœbæ coli, as seen in the stools of a case of dysentery, are rounded or somewhat irregular protoplasmic masses, usually measuring .012 to .035 mm. in diameter, though larger forms are met with. The amœba has an enveloping ectosarc of clear material and an endosarc of granular protoplasm. It possesses a homogeneous, refractive nucleus, and usually several vacuoles are to be seen in its protoplasmic body. Sometimes it contains red corpuscles—which appear to undergo digestive liquefaction—and also bacteria. The amœbæ break down with some rapidity outside the body, and examination of dysenteric stools twenty-four hours after being passed usually fails to detect any of them. They were once thought to have been successfully cultivated in hay infusions, but it is now recognized that the results obtained were erroneous. In the stools they are most

numerous in the small grayish-yellow collections of pus. They are less frequent in the blood-stained mucus, and are rare in the greenish masses of detritus. On a warm slide, these organisms show active movements. The amœbæ frequently penetrate into the intestine; being found in the mucous membrane when ulcers are being formed, and sometimes making their way into the submucous and muscular coats. In tropical abscess of the liver the amœbæ are usually to be detected, and not infrequently are the only organisms present. It is unknown in what form the organism survives outside the body and leads to the propagation of the disease. If it possesses the qualities common to other amœbæ, it is quite probable that conditions are found in both water and soil, especially damp and marshy soils, which favor its existence and development.

In investigating an epidemic of dysentery in which amœbæ could not be found, Ogata observed in the discharges, but especially in sections of the affected tissue, enormous numbers of small bacilli, sometimes in practically pure cultures. These bacilli he regarded as the cause of the disease, and his work has been confirmed by Shiga, Flexner, Strong and others. The specific bacilli vary in their morphology with the nutrient medium used. On agar cultures they appear as short rods, and not rarely in pairs; in old bouillon cultures the rods are very much longer. The organism presents no capsule, forms no spores and possesses no flagella. Staining is readily accomplished by ordinary methods, the bacillus being decolorized by Gram's method. It can be cultivated on the usual media at room temperature; it does not liquefy gelatin nor does it coagulate milk. Litmus milk is slightly reddened after twenty-four hours. The bacillus is pathogenic for rats, mice and rabbits when injected subcutaneously; but when injected into the rectum it does not produce dysentery in the lower animals.

Predisposing Causes.—Dysentery occurs both endemically and epidemically in all climates. For the decade 1888–97, the admissions for this disease, among British soldiers in India, China, Straits Settlements, Ceylon, West Indies, Egypt and Cyprus, and Mauritius, amounted to an average of 15.17 per thousand, while for the United Kingdom they were .5, and for Canada .1 per thousand. In our own army, for the fourteen months, May, 1898, to June, 1899, inclusive, the deaths from diarrhœa and dysentery are given as 1.3 per thousand of troops serving in the United States; 5.69 for those serving in Cuba; 2.08 for those in Porto Rico and 2.48 for those stationed in the Pacific Islands. For the last six months of 1897 the admissions for dysentery in the Spanish army in Cuba amounted to 72 per thousand strength; the death rate to 10 per thousand strength. In temperate climates, summer is the season when this disease, like all diarrhœal affections, prevails to the greatest extent; in the tropics it occurs most frequently at the close of the rainy season. Few facts in connection with the relation between dysentery and climate or season are more clear than those which indicate the influence of vicissitudes of temperature and exposure to chilling in determining attacks. The reduction of dysentery in the French army has been thought to be due, to some extent, to the provision of conveniences which render unnecessary the chilling of the soldiers at night while attending to the calls of nature. Dysentery, though occasionally occurring in dry places, manifests a decided preference for damp and water-logged soils. Of great importance in its epidemic occurrence is the saturation of the

site of the camp or post with organic and particularly fæcal material. The terrible epidemics of former times undoubtedly resulted chiefly from long occupancy of camp sites, resulting in fouling of both the soil and water. All cachectic states of the constitution powerfully predispose to dysentery. Scurvy and malaria are no exceptions to this rule, and the latter gives rise to a form of the disease peculiarly resistant to treatment. Fatigue, exposure, hardship and anxiety also appear to have no small influence in determining its occurrence. A faulty dietary, especially as found in insufficient, coarse or improperly cooked food, green or over-ripe fruits, an excess of salt meats, or the over-use of alcoholics, notoriously favors dysentery. These points were particularly well illustrated by the happy change in the condition of the British army in the Crimea, in respect to the prevalence of dysentery, as soon as its wants as to diet, shelter and clothing were properly satisfied.

A large number of outbreaks of dysentery have occurred during the prevalence of typhoid fever, the development of both apparently being favored by the same general conditions. Several striking illustrations of this fact have lately been recorded among our troops in the Philippines.

Dysentery is particularly liable to affect young soldiers, through their disregard of matters of hygiene and probably greater individual susceptibility. Tripler states that during the war with Mexico the death rate from dysentery was twice as high in the newly raised troops as in the old army. Negro troops appear especially liable to contract dysentery. In our own service, for the decade 1879–88, the relative rates per thousand strength were as follows:

	Admissions.	Deaths.
White troops	13.65	0.20
Colored troops	29.65	.32

In the British forces stationed in the West Indies, for the decade 1888–97, the rates for dysentery among European troops, per thousand strength, were 6.9 for admissions and .33 for deaths. For the same period, the rates for the native negro troops were respectively 16.8 and .44. Coustan, on the other hand, notes an immunity to this disease among the natives of northern Africa, citing an instance where "a French column in Algeria suffered severely, while the native Arab followers, who set every law of hygiene at defiance, escaped sickness." From the greater care which they are able to give themselves, and to their greater attention to sanitary detail, officers are much less liable to contract dysentery than are enlisted men.

Method of Infection.—The commonest recognized portal of infection is the mouth, the specific exciting cause of the disease gaining entrance in contaminated water or on uncooked foods. Experiments show that infection can occur through the rectum, but this is probably a rare mode in human beings. The instances in which outbreaks of dysentery have been traced to the use of impure water, particularly that contaminated with fæcal matter, are very numerous; and of all causes contributing to the occurrence of this disease, that of impure water is the most important. In most instances, this fluid merely serves as a vehicle for the introduction of the specific cause into the system, but it may at times have a predisposing influence through its irritative action on the bowel.

Prieur has reported an epidemic of three hundred and fifteen cases of dysentery occurring in 1891 in a small garrison in the French army, which

he regards as directly traceable to the use of the common latrine by the first patient, who, as the affection became more advanced, was unable to keep from voiding his discharges on the floor and seats. No other case appeared until six days after the first case was well developed. He believes that the subsequent infections were directly due to the dysenteric discharges being mixed with the dirt on the floor of the latrine and then being carried into barracks on the shoes of the soldiers. The food of the latter was then contaminated with this infectious material; a result rendered very possible by the absence of mess-rooms in French barracks and the fact that the soldiers usually sit on stairways or on the floors of halls or barrack-rooms while eating their food.

Prophylaxis.—This is dependent on the etiology. All drinking-water should be protected from contamination, and when open to the slightest suspicion should be sterilized by heat. It is well to keep in mind that if pure water be not provided in a hot climate, the men will get it from any source, however impure. Food should be carefully watched in respect to its sufficiency, quality and the thoroughness of its cooking. When an outbreak of the disease threatens, all raw fruits and vegetables should be excluded from the diet; and, if possible, hard bread and beans, which are difficult of digestion and hence irritating to the intestinal canal. Chilling, especially of the abdomen, should be avoided, and the use of the flannel band may become advisable. The camp site should be dry and well drained. If the disease appears with any severity, the camp should be promptly moved without waiting for further developments. Instances have been known where regiments were affected with dysentery every time they encamped on a certain space, and old camping grounds notoriously favor the occurrence of this disease. The camp should be carefully policed to limit the fly plague, and the contents of trench latrines disinfected and covered twice daily. If possible, the excreta should be burned. Any part of the latrines liable to be soiled with ejections should be disinfected twice daily with suitable solutions. Great care should be taken to prevent contamination of the water supply with fæcal matter, either from the location of the latrines or from uncleanly habits on the part of troops. Dysenteric patients should preferably be removed from the locality in which the disease was contracted; this being an important factor in securing recovery in many cases. Inasmuch as dysentery occasionally spreads in hospitals where large numbers of such cases are under treatment, the necessity of free ventilation, abundant air space and the prompt disinfection of the stools, bed-pans, commodes and enema-tubes are matters of the first importance. It is essential that during an outbreak of dysentery all men affected with diarrhœal symptoms should at once report for treatment for the same.

Enteric or Typhoid Fever.

Occurrence.—The history of enteric or typhoid fever, as a disease of soldiers, extends over a period of scarcely fifty years; it having been previously confused with several other affections. About half a century ago, the disease was differentiated from typhus fever by Murchison; both previously being classed together by medical officers as "spotted fever," and undoubtedly much of the fatality which, prior to this time, had been re-

garded as due to typhus was in reality due to typhoid infection. For a long time, no distinction was made between enteric fever and the continued malarial fevers. Shortly before and during the Civil War, however, medical officers were forced to recognize the different characteristics of typical cases of these diseases, and about the same time the term "typho-malarial" was adopted to cover that class of cases which, while they presented some of the clinical symptoms of both diseases, were apparently identical with neither. Later, the fact that most of these cases of "typho-malarial" fever were in reality typhoid infections was strongly suspected; but it was not until Laveran, of the French army, discovered the malarial parasite that the differentiation between enteric and malarial fevers was definitely made. In the French army, the official recognition of the existence of a disease intermediate between malaria and typhoid was withdrawn in 1888, and about the same time the term "typho-malarial" was discontinued in our own medical nomenclature. This example has since been followed in all the more important armies, and military statistics for this disease, for the past ten years, may be regarded as much more accurate. In the Russian army, however, even as late as 1897, no small proportion of the continued fevers were classed as "undetermined" in nature. It is obvious, therefore, from the difficulty which has until recently existed in the recognition of typhoid fever, that statistics for the periods prior to the past decade are of little value for purposes of comparison between different armies—and even for the same service they are not free from error. For our own army, it may safely be assumed, from a better knowledge of the nature of the typhoid infection, that cases which have been recorded as "typho-malarial" were in reality chiefly cases of enteric fever. In a few instances, however, the typhoid and malarial infections appear to be present at the same time.

Typhoid fever, at the present time, is by far the most important disease affecting soldiers. While it prevails to some extent among troops in garrison, it is among soldiers in the field, and especially those in camps of more or less permanency, that it makes its greatest ravages. This fact depends merely upon the greater difficulty of properly disposing of the excretions of the human body under the latter circumstances. In this country, as in all temperate or tropical regions, enteric fever is so prevalent and its specific cause so widely disseminated that no encampment of any size or permanency can be expected to remain free from its infection. Thus in the camps of our army, during the war with Spain, not a single regiment of those composing six army corps escaped infection. According to the board appointed to investigate the epidemics of typhoid fever during this war, more than twenty thousand cases of this disease occurred among our troops encamped within the limits of the United States during the summer of 1898; nearly all the regular troops and ninety per cent. of the volunteer regiments developed typhoid fever within eight weeks after going into camp —some as early as three weeks—and in the northern quite as much as in the southern parts of the country. This condition, far from being unusual, is what has commonly prevailed in the past among troops of all nations on active service; and Davies gives a number of instances of early epidemics occurring in successive British military expeditions. The recent Anglo-Boer War in South Africa was no exception to this rule. It has been repeatedly observed, especially in the camps of 1898, that while

troops in camp are heavily scourged, the surrounding civil population may remain wholly unaffected. The conclusion is inevitable that the conditions ordinarily found in military encampments, or governing troops in the field, are extremely favorable to the propagation of this disease; this fact being abundantly demonstrated by figures for our own service. During the Civil War period, 1861–66, the admissions for typhoid and "typho-malarial" fevers amounted to 57.71 per thousand strength, while for the sixteen years following the war, 1868–84, the admissions for the same cause were only 6.29 per thousand strength. Again, in 1898, during the war with Spain, the admissions for typhoid fever were reported as amounting to 88.55 per thousand strength, while the board which investigated the epidemics of the disease which occurred during that year, and which critically reviewed the official records, states its belief that these official figures should be raised to 192.65. During the year 1897 the admissions amounted to 6.25, and during the decade 1885–94 they were only 5.51 per thousand strength.

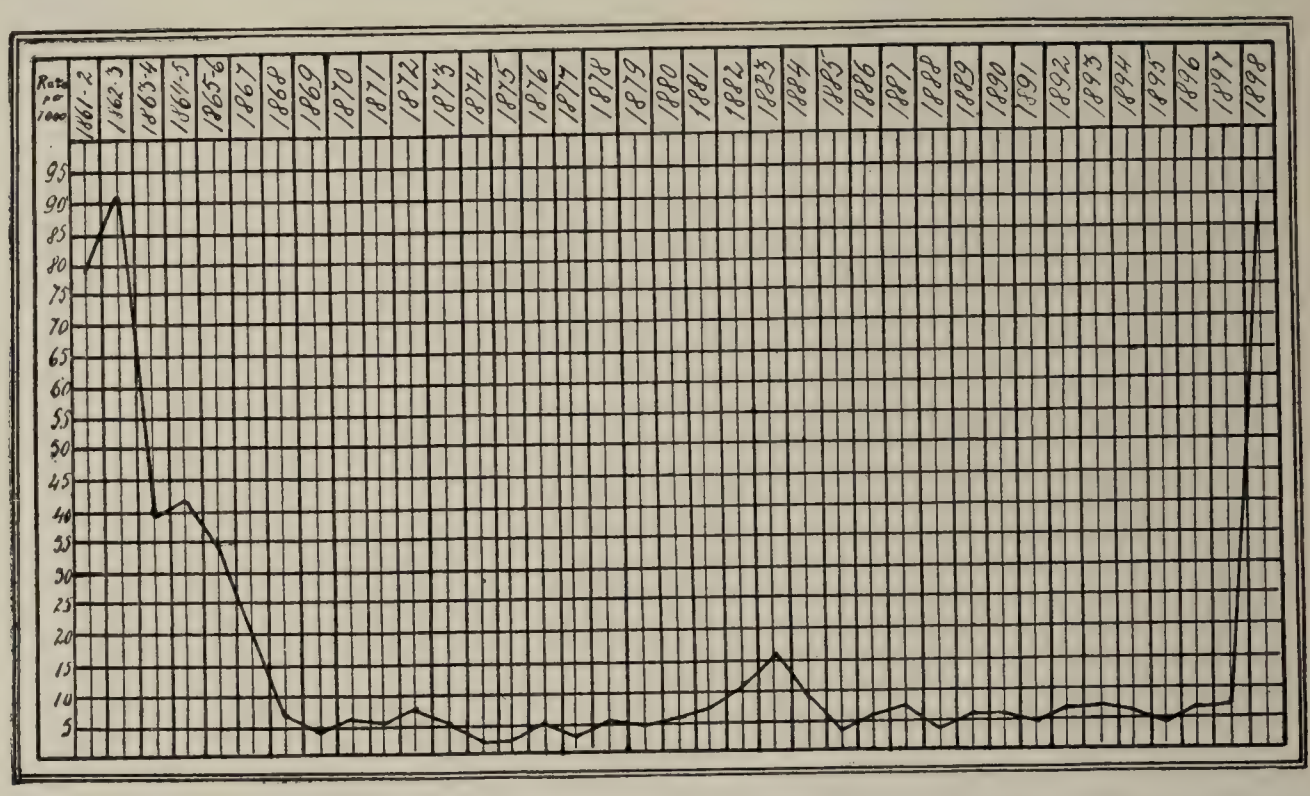


FIG. 331.—Admissions for Typhoid and "Typho-Malarial" Fevers, per Thousand Strength, occurring in the United States Army during the Period 1861–98, excluding the Year 1867.

Throughout the period of peace 1868–97, the rates for typhoid fever showed no very great variation except for the years 1882 and 1883, when sharp localized outbreaks of the disease occurred, and for the years 1874 and 1875, when the rates fell much below the normal. Of late years the disease has shown a tendency to become more prevalent, in spite of the much improved sanitary conditions under which the soldier now lives. It is possible that the comparatively recent reduction in the period of enlistment, from five to three years, through the greater proportion of more susceptible material in the army which is thus brought about, has had an effect in neutralizing sanitary improvements as far as their influence on enteric fever has been concerned. The relative prevalence of typhoid fever in our service since the year 1860, together with the remarkable increase induced by camp life, is shown by the above diagram.

During time of peace, the mortality from typhoid is not high in our army as compared with that for the country at large. For the year 1896 the death rate was .48 per thousand; this being lower than the typhoid

mortality rates in most of our large cities, as Washington, Chicago, Pittsburg and Philadelphia, notwithstanding the greater susceptibility of men of the military age to this disease. In the French army, however, Coustan states that the relative amount of sickness due to typhoid fever is five or six times greater than among the civilian population. Brouardel showed that for 183 French towns, for the period 1886–90, the death rate from typhoid fever for all ages of the civil class was .56 per thousand; in young men 20 to 25 years of age the proportion of deaths was .72 per thousand, where Viry estimated the true army mortality at 2.6 and Marvaud at 2.1 per thousand. During time of peace there has been no great epidemic of this disease in our army; the highest rates of admission being given in the years 1882 and 1883, when the admissions per thousand, for the entire army, amounted to 11.23 and 15.06 respectively. The rates are undoubtedly kept low through the fact that our troops have in the past been scattered in small commands over a large area, and that the infection of an individual water-supply was therefore not able to affect a large number of troops at once, as is often the case in foreign armies. A considerable proportion of those exposed to the typhoid infection have at times contracted the disease. Viry and Coustan cite epidemics in the French army, in 1875, in which 10 per cent. of those exposed contracted the disease at Nanly, 18 per cent. at Saratory and 25 per cent. at Brest. In 1889, of the troops at Dinau, 60 per cent. contracted typhoid during a single epidemic. The board which investigated this disease during the war with Spain concluded that not less than one-fifth of all the troops located at the camps of mobilization had suffered from typhoid fever, either in recognized or unrecognized forms. It also stated that in all probability the deaths due to typhoid fever amounted to more than eighty per cent. of the mortality from all diseases during that period.

With regard to the occurrence of typhoid fever in foreign armies, Coustan gives the rates in the French army as follows:

	Admissions per 1,000 strength.	Deaths per 1,000 strength.		Admissions per 1,000 strength.	Deaths per 1,000 strength.
Before 1888....	From 12–31	2.5	1891.....	10.77	1.95
1888.....	13.2	1.7	1892.....	12.12	1.54
1889.....	11.6	1.6	1893.....	9.59	
1890.....	10.5	1.71			

Before the year 1888, typhoid fevers and continued fevers were classed together. Up to 1893, typhoid was the cause of about one-third of all the deaths occurring in the French army. Marvaud gives the case mortality in this disease, for the period 1878–90, as about sixteen per cent.

In the German army reports the rates of admission and death for typhoid fever, per thousand strength, are given as follows:

Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1881–82 to 1885–86	5.6	0.46
1886–87 to 1890–91	3.6	.28
1891–92 to 1895–96	2.0	.21
Year 1895–96	1.7	.19
Year 1896–97	1.3	.16

The small proportion of cases of this disease, together with the reduction in rates which has steadily taken place, shows most forcibly the admirable sanitary condition of the German army.

In the Russian and Austrian armies, the admission rates have of late years been as follows:

Year.	Russian army, per 1,000 strength.	Austrian army, per 1,000 strength.	Year.	Russian army, per 1,000 strength.	Austrian army, per 1,000 strength.
1890.....	9.6	....	1894.....	6.7	3.7
1891.....	7.9	....	1895.....	7.7	3.1
1892.....	7.6	5.7	1896.....	7.9	3.5
1893.....	7.2	14	1897.....	8.4	3.8

In 1897, the death rate for the Russian army from typhoid fever was 1.37 per thousand strength.

The admission rates for the British army, at home and on foreign service, is given elsewhere in this section. In the Spanish army, according to Coustan, the admission rate for the year 1886 was 12 per thousand.

For the Italian army, the mortality from typhoid has recently been as follows:

Year.	Death per 1,000 strength.
1893	1.12
1894	.84
1895	1.15
1896	1.10
1897	.98

In the Belgian army, for 1898, the death rate from typhoid was .28 per thousand strength.

Cause.—Typhoid fever is caused by an invasion of the organism by a specific microbe—the bacillus typhosus. This is a short, flagellated bacillus, actively motile in liquid media and not forming spores. It does not liquefy gelatin. It presents a very close resemblance, both in structure and habits, to the bacillus coli communis; from which, however, it is specifically distinct. It may be readily cultivated in the usual media, in which it multiplies freely. It flourishes best in the presence of oxygen at about 37° C., and ceases to grow below 9° C. or above 42° C. It does not possess the property, possessed by the colon bacillus, of fermenting glucose, nor of producing indol as a product of its growth in ordinary nutrient media. It does not coagulate milk. On the surface of gelatin plates the colonies have a translucent, filmy appearance, with irregular outline, thin at the margin and thick and less translucent at the center. Those growing in the depths appear as dots, whitish in reflected and brownish in transmitted light. Grown on potato it appears as a transparent film. It is readily destroyed by a few moments' exposure to the boiling point or half an hour's exposure to 60° C. Neither freezing nor the intense cold of liquefied air (−310° F.) destroys it. The bacillus maintains its vitality in water, either fresh or salt, for a considerable time, but does not multiply in water to any extent. Westcott, however, reports an epidemic in which the disease appeared to be produced by water from an infected well which had been closed for twenty months. It maintains its vitality for many weeks

when mixed with sand or earth and partially dried, and may then be blown about as dust. Complete desiccation destroys the bacillus in a short time, but it may long retain its vitality in relatively dry material. Uffelmann showed that layers 4 mm. thick might live thirty-two days on wood, sixty days on linen and eighty days on woolen fabrics. The longevity of typhoid bacilli in soil has been discussed to some extent in connection with the subject of camp sites, and their great vitality in organically polluted soil noted. A recent experiment, with reference to this point, may here be mentioned. Samples of dirt were obtained by Martin from various sources; some from localities where it was known that the soil was largely contaminated with organic matter and where typhoid fever had been endemic, while others were obtained from places which had not been contaminated by sewage or in any other way. These samples of soil were pulverized, placed in flasks and sterilized, after which they were inoculated with cultures of the typhoid bacillus. It was found that the typhoid bacillus grew luxuriantly in the polluted earth, and that flasks containing such soil showed active growths of this micro-organism after the lapse of one hundred and five days. The results obtained with the unpolluted earth were quite different; in these soils the germ not only failed to multiply, but after a short time it died out. The necessity for careful policing of the camp site, together with removal of the camp to fresh ground at frequent periods, is thus obvious.



FIG. 332.—Typhoid Bacilli, Showing Some Filamentous Forms. (After Muir and Ritchie.)

Exposure to diffuse light greatly impairs the vitality of the bacillus, and direct sunlight destroys it. Unfortunately, when present in typhoid stools the latter are not spread out in a thin sheet where sunlight would have its full effect. When cultivated in artificial media, the bacillus rapidly loses its virulence, which can be restored and intensified to the highest pitch by successively passing it through the peritoneal cavities of susceptible animals.

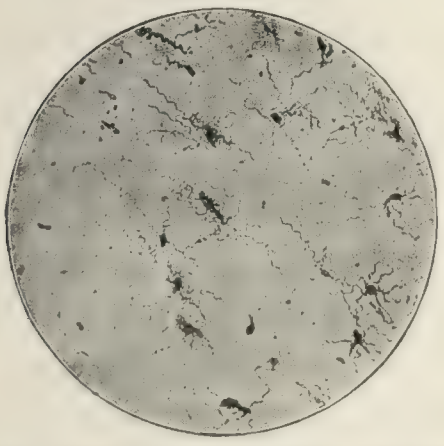


FIG. 333.—Typhoid Bacilli, Stained to Show Flagella.

Elimination of Infectious Material by the Sick.—It has long been recognized that the fæcal discharges of typhoid patients contained the specific bacillus and were a potent factor in the dissemination of the disease. The enteric bacilli, however, are not usually found in the stools earlier than the seventh day—although the latter are probably infective during the incubation period and certainly during the onset of the disease—and they ordinarily disappear soon after convalescence is established. In some cases, however, they have been found as late as forty-one days after defervescence. The stools appear to gain in infectivity for several days after discharge from the sick person, but the reasons for this increase in virulence are not as yet understood.

The elimination of typhoid bacilli by the kidneys affords a ready means of spread which has not sufficiently engaged the attention of medical officers; and in considering the cause and spread of typhoid fever in military

camps this mode of dissemination is too often overlooked. Enormous numbers of the bacilli are frequently, though apparently not invariably, present in the urine. When they do occur, it is late in the disease or during convalescence. In thirty-eight cases, Richardson found the bacilli present in nine; always in large numbers and practically in pure cultures. They appeared only in the later stages of the disease and persisted far into convalescence. Smith found them present in three out of seven cases examined by him, and observed that they may be present in sufficient numbers to render the urine turbid. Petruschky found typhoid bacilli in urine two months after the temperature had become normal, and calculated that in one instance the urine contained 170,000,000 typhoid germs in each cubic centimeter. In many cases the urine during convalescence has been found to be swarming with typhoid bacilli, while none could be detected in the fæces. In certain instances, this condition has been found to persist for years. Richardson has reported an old case of cystitis in which the bacillus was found in pure culture in the urine five years after the attack, and similar results have been obtained by Houston and others. Horton-Smith found that the specific bacilli are present in the urine in apparently one-fourth of the cases of the disease, and that, when present, they occur in far greater numbers than in the fæces. In comparing the two as to the most dangerous and frequent cause of the disease, he concludes that this is "the urine—and this partly on account of the enormous numbers of bacilli which may occur in it, and partly on account of the excretion itself. Thus the stools by their color and odor at once attract attention, so that the slightest soiling of the linen is at once noticed and the damage rectified, but the same cannot be said of the urine." It can readily be understood how a convalescent from typhoid, prematurely returned to duty, could infect the soil of his company camp by urine surreptitiously passed at night; where such contamination by fæcal matter would scarcely be possible, and if it occurred would be readily recognized and measures promptly taken to limit its evil effects.

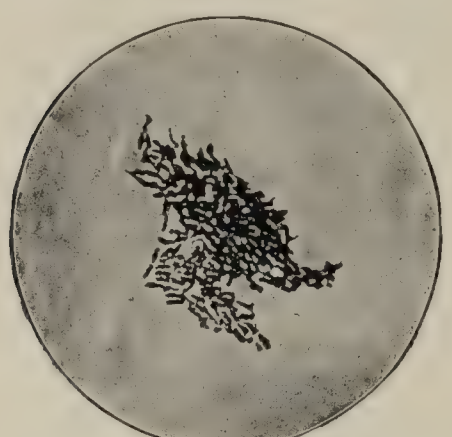


FIG. 334.—Typhoid Bacilli in Urine of Convalescent, after a Relapse and Two Days After the Temperature had Permanently Become Normal. (After Horton-Smith.)

It has recently been questioned whether the sputum in typhoid fever may not be infectious. Investigation on this point by Williams and others has given positive results in a number of instances. How early and how frequently the bacilli appear, and how long they may persist, are matters which have not as yet been determined.

Methods of Dissemination Among Troops.—The typhoid bacillus undoubtedly obtains entrance into the system by being swallowed, either with the water or food, by drawing into the mouth or pharynx the germs suspended in the air or by placing some specifically contaminated object in the former.

In the epidemics of towns or large garrisons, water usually serves as the vehicle for the infective agent; but in camp there are many modes of infection, and in the typhoid epidemics of 1898 contaminated water was one of the least important factors. Vaughan says: "There probably were

local water supplies that became specifically infected with the typhoid-fever bacillus, but infected water was not the great factor in the causation of this disease "—and this opinion will be shared by those who had experience in field service during the period named. At Jacksonville, Lexington and Knoxville the troops used the same water-supply as the civil population, yet the military class had typhoid and the other did not. At Jacksonville there were only a few sporadic cases in the city, while in the adjoining camp, with about the same population, the admissions were sixty or seventy per day. In Knoxville not a case occurred among the citizens at a time when there were hundreds of cases among the soldiers encamped near by. In time of peace, however, the part played by drinking-water, in the occurrence of typhoid, is very great. Instances might be multiplied indefinitely to prove this point, and among these instances perhaps the best examples have occurred in the military service—and particularly in the French army. For the year 1886, among the French troops, the number of cases of typhoid fever amounted to somewhat over 14 per thousand strength. In 1894, these had been reduced to slightly less than 6 per thousand strength; the result being obtained by an almost progressive yearly decrease. In 1895, the Minister of War reported that in 29 garrisons formerly extremely subject to typhoid fever, in each of which an uncontaminated supply of drinking-water had been provided, there had followed an almost total disappearance of this disease and the few isolated cases which occurred were shown to have originated outside the barracks. In those cases in which a new water-supply had been provided and the water was drunk unfiltered, epidemics followed from time to time on the contamination of the source and disappeared after the introduction of Pasteur filters. At Avesnes, after the installation of these filters, 105 cases in 1891 became, for the next three years, only 1 annually. At Auxerre, 129 cases in 1892 were reduced to 1 each in 1893 and 1894. At Melun, 122 cases in 1899 fell to an average of 7.4 for the following five years. At this last post, in February, 1895, 28 dragoons were suddenly attacked, the infantry battalion in the same garrison not having a case. Investigation showed that the filters had been allowed to freeze and the soldiers had been ordered to drink only the weak infusion of tea, in which the water had been boiled, furnished them. The dragoons had not obeyed and had helped themselves to water from the hydrants. At Cherbourg, with a previous annual average of 114.5 cases, the installation of Pasteur filters in 1890 reduced the cases to 28, 8, 11, 3 and 3 in the succeeding years. At Dinau, with a previous annual average of 278 cases, the installation of Pasteur filters in 1890 reduced the number of cases to 1, 2, 3 and 1 respectively, during the next four years. At Lorient, before 1890, there was a yearly average of 170 cases of typhoid fever among the garrison. In 1890, filters were set up, with the result of a decrease to 58 in that year while the cases during the three following years numbered 2, 1 and 1 respectively. In 1894, water was brought into the barracks of this garrison from a spring supposed to be pure, and 11 cases of typhoid shortly appeared. On examination, the water was found to be contaminated and upon its disuse the disease practically ceased to exist among the garrison. Viry states that of 194 epidemics of typhoid fever occurring in garrisons of the French army during the period January 1st, 1887, to January 1st, 1890, no less than 187 of them could be

directly associated with a "defective, doubtful, mediocre or infected water-supply." Many instances of the relation of typhoid fever to drinking-water of bad quality have occurred in our own army; thus at Jefferson Barracks the typhoid which prevailed endemically at that station greatly diminished when a purer supply was substituted.

Except in rare instances, examination of a water-supply during an epidemic of typhoid has failed to reveal the specific germ of this disease; it has, however, usually determined the presence of the bacillus coli communis, showing the probability of infection with typhoid discharges. In character, an epidemic of typhoid due to a single infection of the supply of drinking-water will be marked by the suddenness of the outbreak and the simultaneous occurrence of a large number of cases. The accompanying diagram gives a typical illustration of the course of a water-borne epidemic. As in most places the water-supply soon regains its purity, no increase subsequently in the number of cases may be anticipated unless a second infection of the

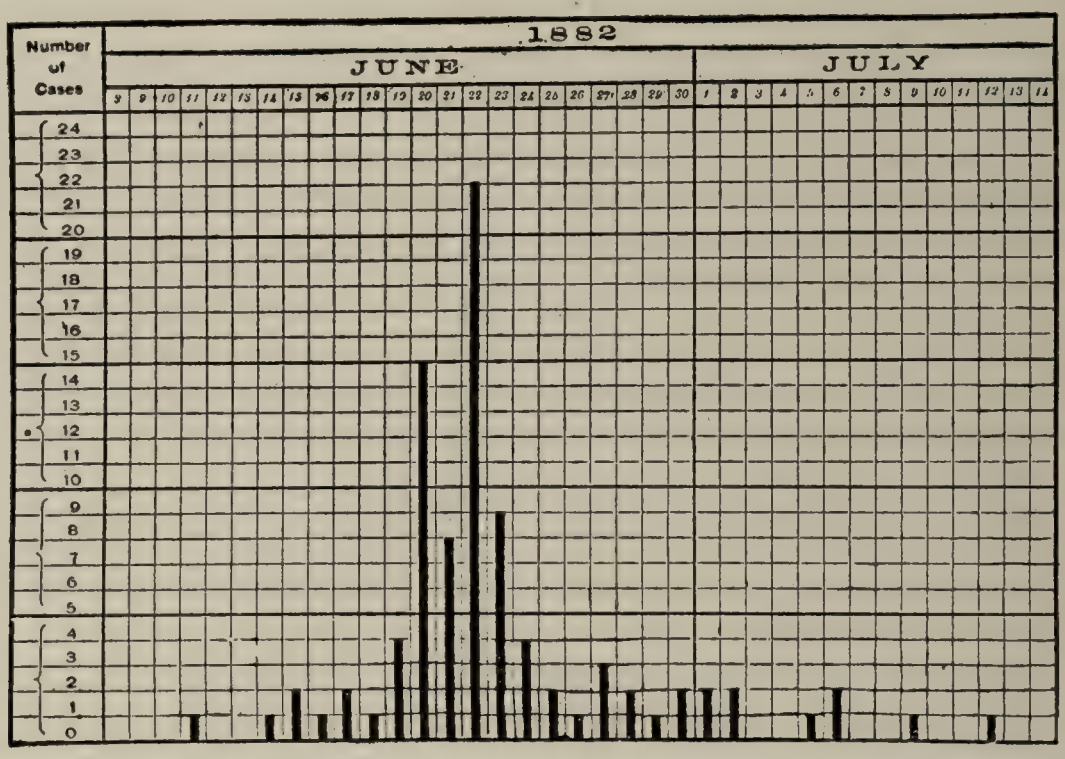


FIG. 335.—Typical Water-Borne Epidemic of Typhoid Fever, Occurring Among the Troops at Wittenberg, Germany. (After Gaffky.)

water-supply occurs. In typhoid spread by other means than water, as in camp epidemics, the onset of the epidemic is gradual. With each case, additional sources of infection are developed and the prevalence of the disease steadly increases as long as efficient preventive measures are not taken and there is an abundance of susceptible material.

Besides the danger of using an infected water for drinking purposes, it is important to recognize the fact that its use in washing the hands, face and other parts of the body may give rise to the disease. Many well-demonstrated instances might be quoted to illustrate this point.

Among articles of food, milk is not infrequently contaminated with typhoid germs from infected water which may have been added or used to wash the dairy utensils. Venders of "soft drinks," so numerous in the vicinity of a military encampment, are usually not at all particular in respect to the quality of the water used in compounding their preparations. During the war with Spain, much of it was probably infected. In the same way, little care is taken to prevent specific contamination, through dust and flies, of the articles of food which such venders expose for sale.

Many articles of food which are eaten uncooked are liable to spread the disease, especially vegetables. Recently an epidemic of typhoid fever occurred in the insane asylum at Northampton, Mass., resulting from the use of celery watered with filtered sewage. Among many similar cases, one was lately reported by Ferre in which an outbreak in a school followed the use of vegetables watered with the contents of a cesspool which received the evacuations of the pupils. Water-cresses grown in ditches contaminated by sewage have been known to serve as the vehicle for the infectious agent. In 1895, Deshon reported several cases of typhoid at a western station which he believed could be traced to the use of heavy, sour and indigestible bread. Among troops in camp during warm weather, the use of food contaminated with typhoid bacilli, brought from the latrines by means of flies, is a factor of the greatest importance in spreading the disease. Numerous observers have demonstrated the presence of the specific bacillus in the excrement of flies made to feed on infected material, and colonies of typhoid bacilli have been shown to develop in the tracks of flies which had been allowed to settle on typhoid discharges and then made to walk over a suitable solid culture medium. Vaughan states that during 1898, in some of the large military camps where lime had recently been sprinkled over the contents of the latrines, flies with their feet whitened with lime were seen walking over the food. He also noted that officers whose mess-tents were protected by means of screens suffered proportionally less from typhoid fever than did those whose tents were not so protected. Where flies are numerous in camp and are constantly settling upon and contaminating articles in common use, it is easy to see that, even if the food and drink be protected from their invasion, an infection may readily be brought about by touching the lips with soiled fingers which have come in contact with articles upon which the typhoid bacilli have been deposited.

The typhoid epidemics of 1898 gradually decreased with the approach of cold weather and the disabling of the fly as a carrier of the infection. Where a strong wind constantly blows from the same direction, a fly-borne infection will extend chiefly down wind; as this insect always rises, and generally moves, in the direction of air-currents. These insects lay their eggs and hatch out in nearly all organic material, especially if this be in a putrid condition. Howard regards horse manure as the most favorable breeding material, but in the camps of 1898 the larvæ were often seen by myriads in the poorly policed latrines. Sprinkling the contents of the latrines with earth, as ordinarily practiced, did not appear to destroy them. Care with respect to preventing organic contamination of the camp space and in carrying out proper measures of latrine disinfection will do much to prevent their development. The life of the fly is short, but the cycle of its development is rapid. According to Howard, under favorable conditions the egg hatches in eight hours, the larva passes to the pupal state in sixty hours to three days, while from pupation to the issuing of the adult requires about five days. As the life cycle is complete in about ten days and the individual insect lays about one hundred and twenty eggs, the enormous numbers in which flies frequently occur in camps are readily accounted for—since twelve to fifteen generations of the pest may be developed in the course of a single summer in temperate climates.

Typhoid fever may also be transmitted by aërial infection from drains,

water-closets, latrines, dust-heaps, urine or fæcal discharges which have been allowed to dry on the linen or person or in receptacles. In this condition, the bacilli are capable of being carried considerable distances through the air to settle down on water, clothing or food. It is not yet determined whether the disease can be contracted by breathing air containing suspended bacilli, but certainly in the case of mouth-breathers the latter should readily find their way to the pharynx and thence be washed into the alimentary canal by the act of deglutition. It is true that complete desiccation soon destroys the typhoid germ; but it is not always completely desiccated, and Flügge and Fischer have shown that this bacillus can successfully resist a considerable amount of drying. Allchin, moreover, states that but a comparatively slight current of air, four meters per second, is sufficient to raise germs into the atmosphere from the surface of wet ground. The dissemination of typhoid by means of infected dust was undoubtedly a potent factor in its spread, in 1898, in the camps at Jacksonville and Tampa. In this connection it is interesting to note that, in 1885, the British troops at certain stations in the Soudan used only distilled water, yet typhoid was very prevalent. No reason for the spread of the infection could be shown except that the excreta were dried, converted into dust and scattered over the camp by the desert winds. In the French army, Nollet was recently able to demonstrate the presence of the typhoid bacillus in the dust of cracks in the barracks at Cherbourg, at which station typhoid had prevailed epidemically. A typhoid infection may long exist in barracks. Thus after the Franco-German War it was found that typhoid fever continued to prevail for some years in German garrisons in which German soldiers or French prisoners, affected with typhoid fever, had lived.

Direct contact with typhoid discharges does much to spread the infection, especially among raw troops. Where lack of discipline permits the pollution of the ground in the vicinity of camps by the indiscriminate deposition of human excreta, a certain proportion of such discharges will assuredly be infected and thus infectious material may be carried into camp and tents on the shoes of incautious passers. Where the men throw their blankets on the ground of the tent area for sleeping purposes, it is obvious that the inhalation of infected dust is more liable to occur. Uncleanly seats in latrines, or the ground therein, may specifically contaminate the persons and clothing of those resorting to them. Where line troops are detailed to do the heavier labor about hospitals, the opportunity for infection to be carried back into camp through their agency is often great. The board which investigated the occurrence of typhoid fever in 1898, was struck with the fact that men who were closely associated in the same company or tent almost simultaneously developed typhoid fever in many instances—apparently through a localized infection derived from the same source.

Heavy rains do much to disseminate typhoid among encamped troops, especially where there is bad sanitary police. Usually the increase in the number of cases after such rains is noticed in about ten days or two weeks. Where sinks are dug in impervious soil and are so located as to receive surface drainage, they may be overflowed by storm waters and distribute their contents over the adjoining surface—these to be later dried and scattered as dust by the feet of men and animals and the wheels of passing wagons.

During the war with Spain, in camps where the tub system for the reception of excreta was in use, careless handling and transportation by the scavengers resulted in the scattering of fæcal matter, much of which was infected, broadcast over the camp area. It may be accepted that wherever a large body of men assemble and their own excretions are permitted to accumulate and contaminate their surroundings, an outbreak and spread of typhoid fever may be expected to occur.

A fruitful cause of the dissemination of typhoid throughout a camp lies in the fact that no small proportion of soldiers, with mild infections or with ambulant cases of typhoid, either do not go on sick report until the typhoid condition is well advanced, or not at all. In many instances, also, the nature of the comparatively slight prodromal symptoms presented are not recognized by the medical officer, and the case for a considerable period is treated in quarters as one of diarrhœa or similar trifling affection. This is particularly true in those instances, noted by Allchin and others as being not infrequent where the individual has been exposed to great hardships, in which the temperature is normal or subnormal throughout the attack. As already stated, the stools in typhoid fever are probably infective even during the period of incubation; and there undoubtedly is a considerable proportion of cases in which an infection does not develop the typical disease, either through an attenuation in virulence of the specific germ or insusceptibility on the part of the subject. In some instances the typhoid bacillus may grow in the intestinal tract of an individual and pass from the same without causing typhoid fever in the soldier serving as host; this probably occurring chiefly when many irritative saprophytic germs are taken in with a relatively small number of typhoid bacilli. The experience of French medical officers in Algiers and Tunis would seem to show that apparently healthy persons may carry the germs of typhoid, which, later scattered under favorable circumstances, originate the disease. British medical officers have noted the same in India and elsewhere. Many instances have been recorded, also, in our own service, especially in the days of Indian warfare, where outbreaks of the disease occurred among troops who had been for considerable periods in regions which were not known to have ever before been penetrated by man. For the British service, an instance of this is furnished by the Afghanistan campaign, in 1878–80; for the French army, in the Oran expedition of 1885, it is stated that commands encamped at desert stations never before occupied, and that typhoid fever not only appeared but assumed epidemic proportions. From such instances, medical officers in all military services have favored a theory of the *de novo* origination of typhoid, or of the metamorphosis of the specific germ from the colon bacillus under suitable conditions. It is easy to understand, however, in the light of recent investigations as to the infectiveness of urine after typhoid fever, and from the fact that typhoid bacilli may retain their virulence for several months when present on infected fabrics carried in the blanket roll, how the microbe of this disease can be transported by troops for long periods, without its presence being suspected, and then give rise to an epidemic when favorable conditions for its development are encountered. Since the period of incubation is ten or twelve days—or even in some cases as long as twenty-three days—it is obvious that infected individuals may be passed as

healthy and sent to other stations, there to develop the characteristic symptoms of the disease and to serve as the starting-point for new epidemics. This was repeatedly shown to have occurred among recruits sent out from Jefferson Barracks—formerly endemically affected with typhoid fever—to western stations. Further, convalescents from typhoid, returned to duty at too early a date, may be unrecognized but potent agents in the origination of the disease in others. All these classes of cases are particularly a menace to the health of a command under canvas, since by their agency every latrine in the camp may become infected and the probability of contamination of the camp space, and perhaps the tentage, by infected urine and saliva, is so great as to approach certainty.

Direct contagion from the obviously diseased to the healthy plays a strong part in the spread of enteric fever. There is no reason for belief that the poison is given off in the breath or the emanations from the body, but it is probably contained only in the urine, fæces and, to some extent, the saliva. If these be properly disinfected and disposed of, strict cleanliness be observed and attention be paid to the disinfection of the soiled linen, the risk of contagion may be reduced to a minimum. Nevertheless it has not been found possible, with all precautions, entirely to prevent the spread of the disease to the attendants. During the typhoid epidemic of 1898, the admissions for this disease from the Medical Department and Hospital Corps were officially reported as amounting to 193.41 per thousand strength, whereas the rate for the army as a whole was 88.56. This fact specifically demonstrated the immediately transmissible character of the affection, and probably was chiefly dependent upon inadvertent infection of the hands or clothing of the attendants. It is important that nurses in charge of typhoid cases should not have the care of patients suffering from other diseases.

Predisposing Causes to Typhoid Among Troops.—Typhoid fever is found in all climates outside the polar regions, but increases in prevalence as the equator is approached. In the British army, distributed as it is all over the world, the prevalence of typhoid varies greatly. For the year 1898 and the decade 1888–97, the rates per thousand of British troops, at different stations, were as follows:

Station.	Year 1898.			Decade 1888–97.		
	Admissions.	Deaths.	Constantly sick.	Admissions.	Deaths.	Constantly sick.
United Kingdom	1.9	0.22	0.31	1.2	0.24	0.20
Gibraltar	4.2	1.32	.74	5.4	.95	1.05
Malta	21.2	6.38	2.44	6.6	2.48	1.15
Egypt and Cyprus	81	23.40	11.12	21.3	4.37	3.90
Canada	.....	.....	.....	1.3	.21	.25
Bermuda	15	2.31	2.36	34.8	6.28	5.13
West Indies	1.1	.55	.23	9	2.15	1.36
South Africa	32.9	5.77	4.88	12.8	1.87	1.93
Mauritius	14.6	4.86	2.37	15	5.34	2.15
Ceylon	2.1	1.43	.09	6.9	2.13	.84
China	1.9	.64	.39	1.5	.50	.21
Straits Settlements	.7	.71	.17	1.9	.88	.29
India	36.3	10.04	4.90	21.8	5.75	3.12

On averaging together the figures for the two cold stations, the United Kingdom and Canada, for the decade 1888–97, the admissions per thousand strength are seen to be 1.25, the deaths .22 and the constantly sick .22. For the same period, the average rates for the remaining stations, located in hot climates or in the tropics, were: Admissions, 12.4; deaths, 2.97; constantly sick, 1.92. From these figures it appears that British soldiers in hot climates or in the tropics are almost exactly ten times as liable to contract the disease as those serving in cool climates; while the liability to death from this disease is fourteen times greater under the former conditions. The apparently shorter course run by typhoid in the tropics, as expressed by the rates for constant sickness, is merely due to the higher rate of mortality, by which the elevation of such figures, through tardy convalescence, is prevented. Coustan states that typhoid fever is far more prevalent in Algiers and Tunis than in France. In our own ser-

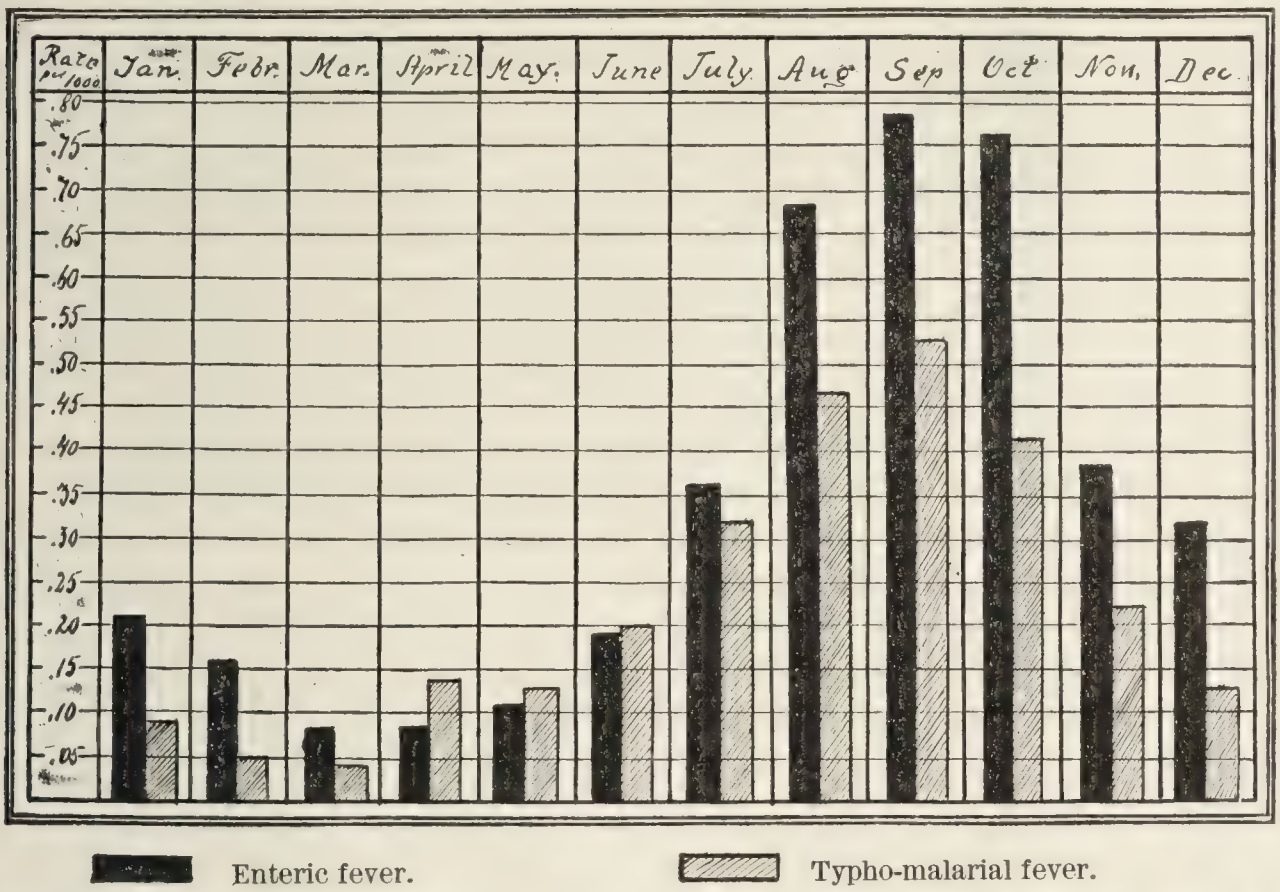


FIG. 336.—Chart Showing the Distribution by Months, per Thousand Strength, of Cases Diagnosed as Enteric Fever and Typho-Malarial Fever, Occurring in the United States Army During the Decade 1875–84.

vice, for the year 1898, the admissions per thousand of troops stationed in the tropical islands were 102.18 and the deaths 13.88; while of troops within the United States during the same period the admission rate was 85.46 and the death rate was 8.79. It should be remembered, however, that troops were exposed to tropical influences but a small part of that year, and that for full periods of service the difference in rates would undoubtedly have been much greater. Thus for the year 1899, under more settled conditions, the admissions to hospital per thousand strength amounted to 27.09 for all the tropical islands and to 10.85 for troops serving in the United States. Within the limits of the United States the influence of locality is marked; the amount of typhoid fever in the Department of Texas being almost twice as high as in any other military department. In 1890 it was more than six times as high as in the Departments of the East, California and Arizona. In 1897 it was fourteen times as high as California and much higher than in the other departments.

As to season, the disease prevails in our army especially during the late summer and early autumn. For the decade 1875–84, as shown by the diagram on the preceding page, the disease occurred least frequently during March and April, and prevailed most extensively in August and September. In the French and German armies it prevails to the greatest extent during and after the manœuvers in August and September; in the Austrian army its prevalence is greater during the July manœuvers. Certain notable outbreaks have occurred in the spring, but these are invariably to be traced to a water-borne infection and are exceptions to the general rule.

Military experience shows that an infection of enteric fever often fixes persistently upon a single barracks, post or district. As a rule, in those localities where the disease is endemic it will be found that unsanitary conditions abound; notably, impure water-supply, defective methods and arrangements for the disposal of excreta, and want of care in respect to preventive measures. In India, typhoid fever has been found to be a more difficult disease to eradicate from military posts than cholera; persisting with great tenacity and recurring year after year in spite of all efforts. It has even been found necessary to abandon stations for this reason. Within these endemically infected areas, new arrivals are especially liable to attack, those long resident appearing to acquire a relative immunity through repeated mild infections. Great importance was attached by Pettenkofer to the height of the ground-water in endemically infected regions; a low ground water, in his opinion, always coinciding with outbreaks of the disease. This relation between typhoid fever and ground-water apparently holds true for certain localities only and need receive no serious consideration.

Negroes and other colored races undoubtedly possess an immunity to typhoid fever. By some this is regarded as a racial characteristic, by others as an acquired immunity resulting from an attack of the disease during childhood. In India, the blood of the natives, as a class, has been recently shown to give a positive reaction with Widal's test in most instances. In our own service, the disease is undeniably less frequent among the negro troops than among the whites. For the period 1867–83, the admissions per thousand white soldiers, for typhoid, not counting typho-malarial fevers as then recognized, amounted to 3.58, while the admissions for colored troops were 2.59 per thousand strength. For the year 1887, the admission rate for white soldiers amounted to 4.25, for colored soldiers .93. During the decade 1887–96 the admission rate among the whites was 5.93 and for the negroes 2.43. It is interesting to note that for our few Indian soldiers, during this latter period, the admission rate for typhoid was only .47. During the year of war, 1898, the relative insusceptibility of negro troops as regards typhoid fever was especially noticeable; the admission rate being 93.24 per thousand white and 27.64 per thousand colored troops—this, too, in spite of the fact that the negro regiments saw harder service. On the other hand, when the disease has actually occurred, the case mortality has been much higher among the colored soldiers than the whites. Typhoid fever occurs only exceptionally among the native troops in India, and their immunity as compared with white soldiers serving in that country has long been noted. As illustrating how great this difference in susceptibility really is, it may be stated that, in 1893, of the forces in India, typhoid fever was responsible for

1.41 per cent. of the sickness and 42 per cent. of the mortality among the English soldiers, and for only .03 per cent. of the sickness and .4 per cent. of the mortality among the native forces. Such an immunity would seem to have an important bearing on the question of raising native forces for controlling our own tropical possessions. For the white race, nativity appears to be a factor of some slight importance. In the United States army, during the seven years 1890–96, the admission rate for typhoid fever from the native-born Americans, per thousand strength, was 5.69; for the soldiers of German nativity, 5.41, and for those born in Ireland, 5.02.

Typhoid fever is especially a disease of young soldiers. How much greater their susceptibility is, can best be appreciated by reference to the accompanying diagram, in which the number of admissions are seen to decrease progressively by almost exactly one-half during each five-year period up to the age of 35. Not only are young men more liable to con-

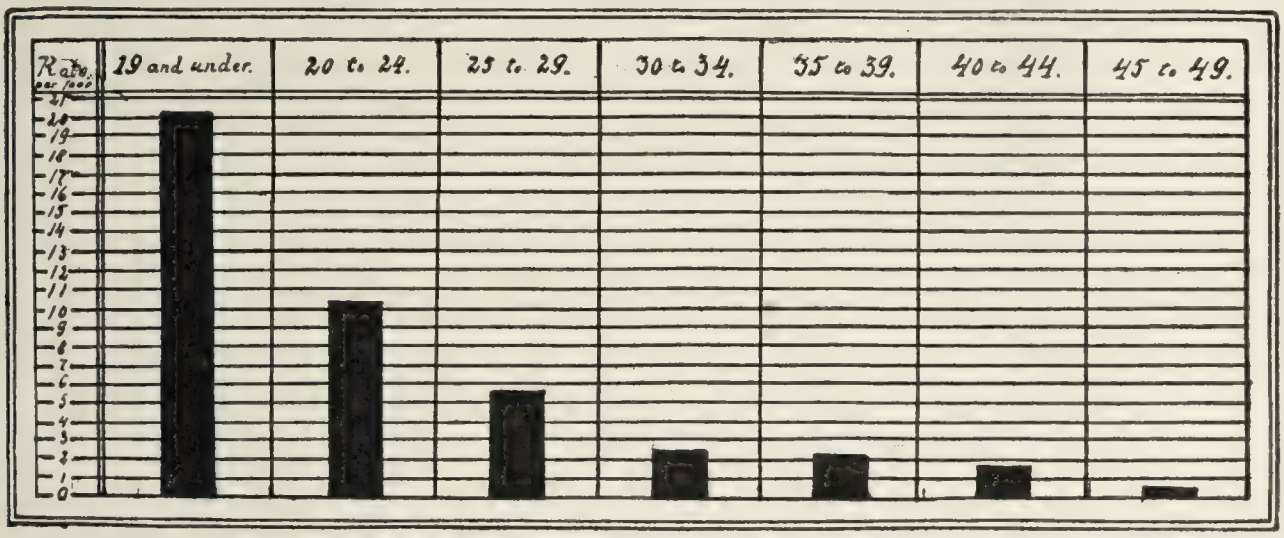


FIG. 337.—Admissions for Typhoid Fever, in the United States Army, per Thousand of Each Class, Arranged According to Age, Occurring during the Seven Years 1890–96.

tract this disease, but the mortality also, among those affected, is higher. For the period 1890–96, in our army, the deaths per thousand of each class were as follows:

Age.	Death rate.
19 years and under	3.32
20 to 24 inclusive	.95
25 to 29 "	.69
30 to 34 "	.23

The case mortality for this period was 16.02 per cent. for soldiers 19 years of age or under, 9.21 per cent. for those 20–24 years of age and 8.89 for those 30–34 years of age.

Length of service, in which factor age must clearly be considered to enter, also markedly influences the occurrence of typhoid. The report of the surgeon-general for 1885 shows the relative prevalence of this disease, excluding small fractions, among men of different periods of service, to be as follows:

Length of service.	Percentage of total deaths from typhoid furnished by each class.
6 months and under	48
Over 6 months and under 12	16
Over 1 year and under 2	14
Over 2 years and under 3	5.5
Over 3 years and under 4	4.5
Over 5 years	7
Length of service not stated	4.5

In respect to English-born soldiers in India, Eyre and Spottiswoode state: "The susceptibility of young soldiers to this fever is clearly shown in the length of residence in India; for while the death rate from typhoid was 4.98 per 1,000 in the first and second years' service, among those in their third to sixth years and seventh to tenth years it was 1.55 and .55 respectively." The report of the Sanitary Commissioner of India, for 1896, states that out of the total number of deaths at all ages from enteric fever, 78 per cent. were between 20 and 24 years of age and 36 per cent. were in the first year of residence. In India, the prevalence of the disease among troops appears to depend chiefly upon the amount of susceptible material presented. This amount of susceptible material is of course variable; but, so far as the United States army is concerned, the board which investigated the typhoid outbreaks during the war with Spain believed that the amount of susceptible individuals in a regiment might be regarded as one-fourth to one-third the total strength.

The influence of the branch of service upon the prevalence of typhoid fever is by no means small. For the period 1867–83, inclusive, the admission rates, per thousand strength, were as follows: Cavalry, 19; infantry, 4.6; artillery, 2.5. For this sixteen-year period, the cavalry thus suffered more than seven times as much from typhoid as did the artillery and nearly five times as much as the infantry, while its death rate was more than three times greater than either of the others. This great difference was largely due to the active field service against Indians required of mounted troops. For the seven-year period 1890–96, the admission rates, per thousand strength, were 8.03 for the cavalry, 5.74 for the infantry and 4.74 for the artillery. In time of peace, the Medical Department is affected less than any of the above arms of the service; during the war with Spain it suffered more than twice as much as any of them.

Overcrowding among troops certainly predisposes to epidemic typhoid fever; Marvaud gives figures to show that in the French army the mortality from this disease bears a well-defined relationship to the number of men aggregated at a post. In camp, the effects of overcrowding are particularly noticeable. This is perhaps due in part to a lowered vital resistance in the individual, but is probably chiefly dependent on the greater intensity of the infection resulting from the rapid propagation of the typhoid bacillus on a soil more highly contaminated with organic material, with a possible acquirement of more virulent qualities under such conditions.

Uncleanliness of person and surroundings is a powerful factor in the development of the disease among soldiers. Particularly is this the case with regard to the care and disposition of the excreta—the most important and difficult problem presented to the military sanitarian in the field. The common method of disposal of excreta and refuse in camp—by trenches and pits—offers many facilities for the development and spread of the specific micro-organisms. All collections of filth are liable to contamination and hence to become foci of infection. In garrison, the accumulation of organic matter under floors, dampened by the seepage of moisture through the use of excessive amounts of water in cleansing, affords excellent facilities for the development of the microbe.

The influence of great fatigue, as a factor in the occurrence of typhoid,

has been particularly noted by medical officers in foreign services. The arduous and exhausting manœuvers which take place yearly in all the larger European armies are invariably followed by outbreaks of this affection. It is well known that by over-exertion the bactericidal power of the blood is diminished and susceptibility to disease greatly increased. Coustan mentions, in connection with this subject, the experiments of Charrin and Roger, in which rats made to turn a wheel until exhausted succumbed readily to inoculation by an attenuated culture of anthrax, while similar animals, not so exhausted, resisted the same inoculation. The loss of life from typhoid fever in infected regiments sent from Chickamauga to Porto Rico, in 1898, was materially greater than among similarly infected regiments which remained behind—probably through the greater hardship and physical strain to which the former were exposed. It is undoubtedly true that, while leaving the system more readily open to invasion by the typhoid germ, excessive fatigue induces more speedy development of the disease in persons already infected.

Insufficient or improper food, through the malnutrition or digestive disturbance which results from its use, may facilitate the invasion of the organism by the typhoid bacillus.

Prophylaxis.—In the prevention of epidemics of enteric fever among troops in garrison, a pure water-supply is of the first importance. With troops in camp, while the water should be of good quality, an early and correct diagnosis of the cases of this disease which first appear is essential in preventing its spread. If the water-supply be regarded as liable to pollution, it should, in garrison, be filtered through the Berkefeld apparatus before being used for drinking purposes. In the field, and sometimes in garrison, water is best sterilized by boiling—preferably by the Forbes apparatus. If the water is originally pure, as water from springs, deep or artesian wells or unpolluted surface-waters, it will only be necessary to ensure against its contamination before use. Where such water is dipped from open barrels with possibly unclean cups and hands, it will be evident that during the prevalence of typhoid fever the contamination of drinking-water in this way may not be rare. The receptacles for drinking-water should therefore be tightly closed and the water drawn off by means of faucets. Since, in camps, enteric fever is more directly propagated from the sick, and since the latter can through their discharges soon disseminate the disease through large bodies of troops, the prompt recognition and isolation of typhoid cases, with the immediate disinfection of their excreta, equipments, tentage and surroundings, is of the greatest importance. As already intimated, the diagnosis of this disease is frequently a matter of much difficulty and may be impossible in all instances, but constant watchfulness on the part of medical officers will reduce this error to the minimum. The board investigating the typhoid epidemics prevailing during the war with Spain concluded that less than half of the cases of this disease which occurred among troops were correctly diagnosed; but stated its opinion that, in recognizing this proportion, the army medical officer probably did better than the average physician throughout the country does in his private practice. Any such error of diagnosis, however, implies too great reliance upon the mere clinical symptoms of enteric fever—which, it has been stated, are frequently modified or largely lacking

—and a too infrequent use of modern and more precise means of diagnosis, as found in the Widal test with blood-serum and the diazo reaction given by the urine. It is obvious that under many conditions of military service, particularly with marching troops, the former test can scarcely be applied, but in a fixed camp or garrison it can usually be carried out—and the technique of the diazo reaction is possible under any circumstances. These tests should be habitually applied to every case presenting fever, the nature of which is not promptly and definitely recognized as being other than typhoid. In view of the great importance of accurate and early diagnosis, even at the risk of encroaching upon the province of military medicine, these tests will be briefly considered.

The Widal method of diagnosis is based upon the fact that living and actively motile typhoid bacilli, when placed in the dilute serum of a patient suffering from typhoid fever, within a short time lose their motility and become aggregated into clumps. For this purpose, either fresh or dried blood may be used. In the military service, the use of the latter will usually be more convenient and appears to give fully as accurate results. With this method, a drop of the blood to be examined is received on a sheet of glazed writing-paper and allowed to dry in the air, and may then be folded and sent to the laboratory in an envelope. At the Army Medical Museum, the fluid medium employed for the growth of the typhoid bacilli required in the test is old one per cent. glucose bouillon. A tube of this bouillon is planted with a culture of the typhoid bacillus, which as a rule has grown on agar for several weeks. The inoculated tube is usually kept at room temperature; since when grown for eighteen to twenty-four hours at 37° C., a loop taken from the lower part of such a tube often shows small masses of agglutinated bacilli. When grown at room temperature, the danger of previous clumping is eliminated and the bacilli are kept in good motility for three to five days. A drop of dried blood is moistened at its margin with sterilized distilled water, so as to obtain a pale straw-colored solution. This is transferred, by the loop, to the center of a clean cover-slip which has been well flamed. Generally the contents of the loops are transferred, and immediately thereafter a quantity of the fluid culture, motility of which has been previously tested, is carefully mixed with the blood solution. The drop is then examined, with a dry lens, to observe motility and agglutination. The time adopted within which the reaction should be complete is one hour. When all motility ceases and the majority of the bacilli are gathered together in small masses, the reaction is positive. If partial agglutination occurs, a few bacilli are still motile, the reaction is incomplete and a second sample of blood is examined subsequently. When the reaction is present only to some extent around the margin of the drop, the reaction is doubtful. The relation of the dilution of the serum is very important; since if the degree of dilution be too small, a non-typhoid serum may cause clumping. If possible, examinations should be made with several dilutions; in general, the more dilute the serum the longer the time necessary for a complete reaction. Of course an accurate measurement of the dilution with dried blood-serum is scarcely possible. While there is a certain small margin of error with the Widal reaction, it appears to be given by the serum in about ninety-five per cent. of all cases of enteric fever. The reaction is usually obtainable about the seventh day of the

disease, though occasionally it has been found as early as the fifth day. Sometimes it has not appeared until the third week or later, and usually it becomes more marked as the disease advances. How long the reaction can be obtained after the end of the disease has not as yet been fully determined, but in many cases it has been found after several months and it probably is given after periods of years.

The Ehrlich diazo reaction is given by the urine in a large proportion of cases of typhoid fever, and possesses considerable diagnostic importance when considered with the clinical history of the case. In performing this test, two solutions, called A and B, are prepared. A consists of a twenty per cent. solution of hydrochloric acid saturated with sulphanilic acid; B of a half per cent. solution of sodium nitrite. Immediately before using, one part of B is mixed with twenty-five parts of A, an equal volume of urine is added to it in a test-tube and strong liquor ammonia is dropped into the mixture or allowed to flow down the side of the tube. At the junction, a crimson ring forms. If the tube be shaken, the froth is colored pink; ordinary urine gives a more or less deep orange color. In applying the test, care should be taken to mix the solution accurately. The reaction often appears before the clinical symptoms of the case are well pronounced.

Since the Widal and diazo reactions may not be given at certain stages of enteric fever, they should be repeated one or more times in possibly suspicious cases.

Where typhoid fever is recognized as existing, the affected individual should be promptly isolated. If in garrison, the clothing and bedding of the patient, together with the water-closet or latrine used by him, should be disinfected. If the case occurs under canvas these precautions are required, and in addition the disinfection of the clothing and bedding of those sheltered with him should be sterilized. The tent itself should be disinfected. If possible the camp, or at least that of the company organization in which the case occurred, should be moved. If this be not possible, the site occupied by the tent should be vacated, policed and exposed to the sun, and should not again be occupied. In many instances it would be desirable, in addition, to freely scatter fresh lime over the entire tent area. Old tent floors should be scrubbed with a strong carbolic solution, stood on edge and sunned on both sides for at least two days before being again used.

Since the nature of many cases of enteric infection in camp will not be recognized, it should be the rule, under conditions of field service, to regard all human excreta as infected and, where a camp has a permanency of more than three or four days, systematically to carry out measures for the destruction of its presumably noxious qualities. The expense of an epidemic of typhoid will be many times the additional cost of these justifiable precautions. In all camps of any permanency, the use of excavated latrines should be prohibited and either the trough system or crematories, as already considered, provided for the disposal of excreta. Under the same conditions, urine tubs should be provided for night use and their utilization enforced. The board which investigated the epidemics of typhoid fever in 1898, found that the number of cases in the different camps varied, in a general way, with the methods of disposing of the excretions. Hence careful policing of the camp, with cremation of refuse, should be carried out to

limit soil contamination and prevent the development of the fly plague. A careful sanitary police is highly effective in preventing the development of these insects in very great numbers; but where the fly plague actually exists, the only recourse is to abandon the infected area for a new site, preferably located to the windward and at a distance of at least two miles. The fact that a command expects to change its location at an early date does not justify neglect of proper policing of the ground occupied. Except in the case of the most urgent military necessity, one command should never be located upon a camp site recently vacated by another.

Other general methods of prophylaxis consist in the allotment of abundant space in the arrangement of the camp; the free exposure of the interior of tents—and of their contents—to sunlight and air-currents; the raising of the bed of the soldier above the ground; cleanliness of person on the part of troops; an abundance of good food and, in time of epidemic, the avoidance of exhausting drills and exercises. It is important that a presumably infected camp site should promptly be abandoned; though if troops be allowed first to become generally infected, this procedure is not as efficacious in controlling typhoid fever as in some other diseases. It is evident that where tents, blankets and equipage which have been infected are carried along with the troops, innumerable cultures of the bacillus are thus transplanted to the new camp site, besides those in the bodies of the infected men themselves.

With respect to the measures to be applied to prevent further spread of the infection from the sick, the proper disinfection of the excreta is of the first importance. All discharges should be received in a solution of milk of lime. The nates of the patient should be cleaned with paper and afterward with a bit of compress-cloth wet with a dilute disinfectant solution. The bed-pan should be covered with rubber sheeting and removed at once. In garrison, the contents of the bed-pan should be thoroughly mixed and allowed to stand for half an hour before pouring into the slop-hopper; in the field they should be burned at once. The practice of burying typhoid discharges, after measures of disinfection by chemical means, is strongly to be deprecated. In certain instances all the bacilli will undoubtedly not be destroyed, and it has been shown that they not only develop in organically polluted ground but may grow upward to the surface through a considerable depth of earth. Even if buried deeply, there is always a possibility of their future disturbance or of their gaining access to a neighboring water-supply. Whether in camp or garrison, the cloth compresses used to cleanse the person of the patient should be destroyed by fire. The bed-pan, rubber cover and slop hopper should be cleansed with disinfectant solution and the two former wiped dry. Both should be placed in a closed receptacle to prevent access by flies when not in use. All sputum should be received in spit-cups containing a disinfectant solution. Feeding utensils should be cleansed with boiling water immediately after use, and any uneaten remnants of food at once disinfected by burning or scalding. All bed-linen, body-clothes and towels soiled by discharges should be immediately rolled in a clean sheet wet in bichloride solution and removed for appropriate disinfection. Bed-spreads and blankets should be sunned and aired as often as possible. They should not be shaken in the sick-room any more than is absolutely necessary. Bed and body-linen should be changed

daily and all soiled linen should at once be disinfected; rubber sheets should be used over the mattresses. Flies should be kept away from the patient, not only for his comfort but to prevent the transmission of his disease to others by their agency.

After attending to the wants of a typhoid patient, the hands of the nurse in each instance should be rinsed in a disinfectant solution and then washed in warm water, using soap and a nail-brush.

The urine of patients convalescent from this disease should be examined at frequent intervals for the typhoid bacillus, and return to duty or quarters before this bacillus has been absent from the urine for a period of at least one week should not be permitted. To effect the sterilization of the urine, when this bacillus is present, Richardson and others recommend the use of urotropin, in ten-grain doses, three times a day. Salol and other substances appear to have little value for this purpose. The return of typhoid patients to their regiments for convalescence in order to make room in possibly crowded hospitals is above all to be avoided.

Preventive Inoculation.—The problem of preventive inoculation against typhoid fever, now receiving much attention, has a special importance for the military sanitarian. Bokenham endeavored to produce a prophylactic and curative serum by the immunization of horses through the repeated injection of living and dead cultures of the bacillus; but the serum thus obtained was not of sufficiently great potency to give it a practical value, and no means could be found of precipitating or concentrating what strength the serum contained. Pfeiffer, Wright and Semple and others then endeavored directly to produce in man the immunity which it was shown could be created in animals. At first these investigators cultivated virulent cultures on agar, making up an emulsion of these cultures with bouillon so that each cubic centimeter contained about 2 mgm. of fresh agar growth. The microbes were then killed by exposure to a temperature of 56° C. for several hours. Of this emulsion, 1 c.c. was used as a dose, the liquid being well shaken. Recently Wright has attained more satisfactory results by cultivating the bacilli directly in bouillon. After incubation at 37° C. for a period of fourteen to twenty-one days, the culture is sterilized by exposure to a temperature of 60° C. for five minutes. This is done by drawing the emulsion into small sterile tubes, which are sealed and placed in a beaker of cold water which is gradually raised to the desired temperature, and this is maintained for the period above noted. Agar tubes are then inoculated with the material to make sure of its sterility. Before injection, one-half per cent. of lysol is sometimes added to neutralize any accidental contamination. The amount used for human inoculation is two-fifths of the minimum amount which would be fatal to a guinea-pig weighing 250 gm. The immunizing material appears to be valuable rather on account of its antimicrobic than its antitoxic properties.

While the reaction following the inoculation is usually slight, it is at times somewhat severe. Rigors, nausea and a tendency to syncope sometimes occur. There is a well-marked local reaction, which, however, never advances to suppuration. When the inoculation is successful, the blood-serum acquires the specific agglutinative property with regard to the bacilli to a marked degree. Cameron found in his own case that at the end of

twenty days the agglutinating power of his blood-serum was increased forty times; and an increase to this extent has been shown by other observers commonly to result. In general, the agglutinating property is equal to that conferred by an attack of the disease itself. It is not known how long the influence of the inoculation persists; and when a protection lasting more than two years is desired, it is recommended to ensure a good reaction by repeating the inoculation after an interval of one week. This repetition appears to be of importance in securing the best results.

At present, experience with these inoculations has not been sufficiently comprehensive to warrant the drawing of exact conclusions. The inoculations have been carried out on a considerable scale, however, with the sanction of the military authorities, on British soldiers voluntarily submitting to the operation before leaving for the recent scene of hostilities in South Africa. Foulerton states that reports so far received from the Anglo-Boer War show that typhoid fever has occurred at the rate of six to the thousand among the inoculated and nine to the thousand of the uninoculated. Figures given by Wright, based upon 11,295 inoculated British soldiers in India, show that .95 per cent. of these contracted the disease where 2.5 per cent. of the uninoculated were attacked. These results, while not brilliant, are certainly encouraging and render the method well worthy of general use among young soldiers detailed for tropical service; particularly since the inoculation, when properly performed, is quite free from actual danger.

Influenza.

Occurrence.—In the military service, influenza is chiefly of importance through the incapacity for duty which it produces. The military age does not include the extremes of life, at which the disease is most fatal, and hence the mortality directly resulting from this affection is small; but that it exerts a certain unfavorable influence in the production of secondary pneumonia and tuberculosis there can be no doubt. The disease in our army has occurred in well-defined epidemics, of great intensity but short duration. During recent years these epidemics have occurred with much greater frequency. Following their subsidence, there appears to have been a tendency on the part of medical officers to confound simple respiratory catarrhs with this disease, even in the absence of any epidemic tendencies—thus probably unduly raising the rates for this affection. During the Civil War, the admission rates for influenza, per thousand strength, amounted to 60.84. For the sixteen years 1868–84, the cases fell to an average of 9.39 per thousand strength. During the decade 1885–94, epidemics in 1892 and 1893 raised the figures for this disease, making the admissions 49.88 per thousand strength. For the period 1895–98, the admission rate was 44.92. For the year 1897, the admissions were again increased to 74.35, while for 1898 they fell to 32.37. In foreign armies, the disease has prevailed among troops during the general epidemics which have from time to time occurred. In 1892 and 1893, high rates for this disease were given in all European armies. In the British army the disease has prevailed nearly every year since 1889. In the Russian service, influenza appears annually as a potent factor in elevating the sick rates.

Cause.—The disease is now generally accepted as being produced by specific bacilli which, as seen in the sputum, appear as very minute rods, staining more deeply at the extremities. These bacilli occur singly or form clumps by their aggregation, but do not grow into chains. They show no capsule, are non-motile and do not form spores. They take up basic aniline stains somewhat feebly and are best stained with carbol-fuchsin. They are decolorized by Gram's method of staining. The bacilli grow best at body temperature and upon the surface of media containing blood or blood-coloring matter, the latter appearing to afford substances especially adapted to the nutrition of this micro-organism. After twenty-four hours, the colonies appear as minute circular, transparent dots. The bacilli die out very quickly in cultures. A small amount of growth takes place in bouillon to which a little fresh blood has been added.



FIG. 338.—Influenza Bacilli in Sputum. (After Abbott.)

Dissemination and Infection.—The powers of resistance of this bacillus appear to be of a very low order. Pfeiffer found that dried cultures kept at the ordinary temperature were usually dead in twenty hours, and that no growth could be obtained from influenza sputum at the end of two days. Their duration of life in ordinary water is also short, the bacilli being usually dead in two days. From these experiments, Pfeiffer concludes that the bacilli cannot multiply under ordinary condition outside the body, and can remain alive for a short time only. The mode of infection in the disease he accordingly considers to be chiefly by direct contact with infective mucus, with which alone the bacilli probably escape from the organism. Its rapid spread over large areas was long thought to be explainable on the supposition that the infection was air-borne, but this is probably due to the combined effect of a short incubation period, an early infectiveness, a general susceptibility and the existence of early unrecognized cases. It is impossible to state exactly the conditions which favor its development and spread, but atmospheric conditions which favor bronchial irritation certainly play a part. The incubation period is from two to six days, and perhaps at times the limits are wider. Infectivity is established early, in many instances before the disease has fairly declared itself. It persists for some time after acute symptoms have subsided, judging by the presence of Pfeiffer's bacillus. While this micro-organism appears to be unable to cause influenza in the lower animals, there is abundant evidence that certain animals suffer with symptoms much like those of influenza during epidemics of this disease. During the severe epidemics of 1892 and 1893, the disease known as "pink-eye," regarded by many as a form of influenza, was extremely prevalent among our cavalry horses.

Prophylaxis.—Influenza is an infectious disease, the spread of which can be checked by isolation; but when the peculiar features of the disease and the conditions of military life are considered, it must be admitted that

isolation has its limitations and can usually only mitigate but not entirely prevent an epidemic. In general, however, it is important to prevent as far as possible the contact of the infected with the uninfected. Soldiers affected with the disease even in a mild form should be taken into hospital, not so much for their own welfare as for the sake of others. While the disease prevails, large assemblages of troops should, as far as possible, be avoided. There should also be an avoidance of all influences that lower the general tone, and good ventilation with cleanliness of person and surroundings are of value. The sputum of affected individuals should be treated in the same manner as if it were tuberculous. All handkerchiefs, napkins, bedding, clothing and other articles used by the sick should be disinfected—though when an epidemic is once established, the infection is usually so widespread that measures looking to the control of the disease are of but little avail.

Malarial Fevers.

Occurrence.—Malaria has ravaged armies in every age and climate, and has frequently modified military operations or brought about their failure. Rome was saved from capture by malarial fevers, which so scourged the besieging Gauls under Brennus as to cause their retreat. In the year 208, the Roman army in Scotland lost 50,000 men out of a total of 80,000 from this cause. No military disaster caused by malarial infection was more complete, however, than that of the British expedition to the island of Walcheren, in 1809. On this occasion it has been said that the British were conquered before the battle. Out of an effective force of 39,219 there succumbed to the fever, between August 28th and December, no less than 23,175 men, while after the return to England there were 11,503 additional cases. But 217 men, during this disastrous expedition, were killed by the enemy. In the Seminole War, in Florida, our troops suffered severely from malarial infections. In the French army before Sebastopol there were 20,623 cases with 2,179 deaths. In the Union forces, during the Civil War, there were 1,314,744 cases of malaria with 10,062 deaths; giving a mortality of 3.92 per thousand strength. "But though the mortality from these fevers was comparatively light, their influence in detracting from the efficiency of the army was very great"—as well as largely influencing the rates of discharge for disability on account of resulting anæmia and chronic malarial poisoning. The so-called "Chickahominy fever" was particularly severe in its effects. Malarial fevers prevailed in the French army during the Italian War and the occupation of the Papal States. Ashmead states that 5,995 Japanese soldiers, sent to Formosa in 1873, furnished 6,105 admissions to hospital, for continued malarial fevers, in a single year. In the French expedition in Madagascar, in 1895, out of a force of 22,850 men—combatants and carriers—there were 7,498 deaths from disease; a mortality of about 33 per cent. Nearly all the deaths were from malarial fevers. During this expedition only 7 men were killed by the enemy and but 94 wounded. In the same year, a Spanish expedition in the Philippine Islands was scourged by malarial fever. During the last insurrection in Cuba, the Spanish forces were largely depleted by malarial infections of a severe type; the admissions to hospital for this cause, during the year 1897, amounting to 420 per thou-

sand strength. In 1898, after the capture of Santiago, one-half of our forces in Cuba were incapacitated for duty at the same time by reason of malarial fevers. This grave condition of affairs evoked an appeal to the War Department, signed by all the officers of higher rank, for an immediate removal of these troops to a more healthy locality—using the sentence: "This army must be moved or perish."

Until within a comparatively recent period, malarial disease, in time of peace, constituted the prime factor in the constitution of the sick reports of our army. To-day, except for a few posts, it occupies a minor position for troops on the home station—the decrease not only having been great but steadily progressive. This reduction has been brought about by the withdrawal of troops from more unhealthful stations and by greater attention to sanitary detail at the few malarious posts at which military necessity requires garrisons to be maintained. During the last quarter of a century,

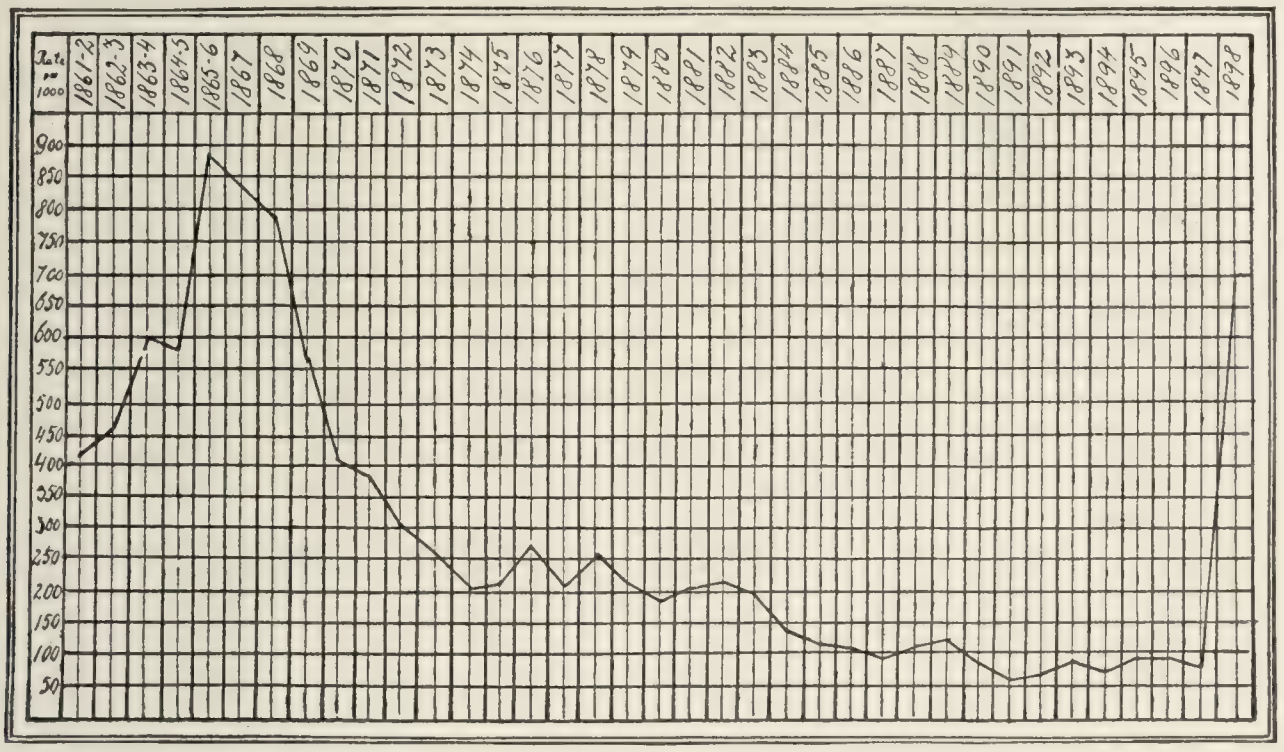


FIG. 339.—Chart Showing Admissions for Malarial Infections in the United States Army, per Thousand Strength, for the Period 1861–98, Excluding the Year 1867.

also, the disease appears to have decreased considerably in frequency, especially in the eastern portion of the United States. The possibility of retaining troops at stations on the Potomac River, as an example, was long a matter for serious consideration. Nearly all the garrison at Fort Myer contracted malarial fevers during the season; of Washington Barracks it was at one time officially reported that during the malarial months there were scarcely enough well men to perform guard duty; and at Fort Washington the prevalence of malarial disease resulted in the abandonment of the post as a station for troops. These posts still lead all other military stations in this country as regards malaria, but the proportionate number of cases of malarial infection is now very greatly reduced. Following the re-garrisoning of Fort Washington, the sick rates at that station have been by no means seriously high.

Since the Civil War, the admissions for malaria for the entire army, per thousand strength, fell from 793.75 in 1868 to 78.88 in 1897. For the period 1868–84, the admission rates, per thousand strength, amounted to 331.06; for the decade 1885–94 they were 92.27. The influence of war,

and especially the exposure to malarial infection in the tropics, caused an increase in the admission rate to 694.60 in 1898. The death rate, also, was unusually high during the last-named year, showing the more grave nature of the tropical infections. The board investigating the occurrence of typhoid fever during the war with Spain came to the conclusion, however, that malaria was a comparatively rare disease among those soldiers who remained within the limits of the United States. As great as has been the reduction of malarial disease in our own army—to one-tenth of its prevalence a generation ago—the improvement in this respect in the German service has been even greater. Official figures for that army are as follows:

Period.	Admissions per 1,000 strength.
1881–82 to 1885–86	14.2
1886–87 to 1890–91	4.1
1891–92 to 1895–96	1.1
Year 1895–96	.55
Year 1896–97	.45

In the French army, the admissions for malaria, per thousand strength, are thus given by Coustan for troops in France and Algeria.

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1875–79	30	1888	13
1880	18	1889	16
1881	25	1890	17
1882	30	1891	36.1
1883	56	1892	24.4
1884	15	1893	14.2
1885	20		

For the British forces on the home stations, the admissions for the decade 1888–97, per thousand strength, amounted to 6.3; for the year 1898 they were increased to 9.5.

In the Russian army, the admission and mortality rates from malarial fevers, per thousand strength, were lately as follows:

Year.	Admissions.	Deaths.	Year.	Admissions.	Deaths.
1890	102.3	7.1	1894	57.6	0.08
1891	79.9	.05	1895	44.5	.06
1892	78.1	.08	1896	46.5	.08
1893	79.1	.07	1897	47.3	.07

In the Austrian army the cases of malaria amounted to 50.3 per thousand in 1885; to 30.6 in 1891; to 40.4 in 1892; to 34.7 in 1893; to 28 in 1894; to 26.1 in 1895; to 22.6 in 1896; and to 31.9 in 1897. The deaths from malaria in the Italian army, per thousand strength, have recently been as follows:

Year.	Death rate.	Year.	Death rate.
1893	0.13	1896	0.12
1894	.10	1897	.08
1895	.12		

Cause.—The organism now recognized as being the causative agent in the production of malarial fever is an animal parasite discovered by Laveran, of the French army, belonging to the protozoa and known under the

name of Plasmodium malariæ. Regarding the invariable presence of this organism in the blood of those sick with the disease, and the cycle of changes which it undergoes in relation to the paroxysms of fever, all are agreed. On the other hand, some doubt still prevails regarding certain periods of development, and especially regarding the number of varieties of the organism and their relations to one another. The view entertained by Laveran is that there is but one species of malarial parasite, which is polymorphous and presents slight differences in structural character in the different types of fever. This view, however, is held by but a small minority of observers. There is now a fairly general agreement as to the division of the varieties of malarial fever, according to the character of the parasite, into two main classes; the first including the milder forms, tertian and quartan, and the second including the quotidian, malignant or æstivo-autumnal and certain irregular forms. In all these types of fever the parasites pass through a definite cycle of development, which is complete in a period of time corresponding to the variety of the fever. The parasites are always most abundant in the blood during the attack of fever, but in the intervals they may become greatly diminished in number or even disappear. They are also, as a rule, more abundant in the internal organs than in the peripheral blood-vessels, and in some types of fever the process of sporulation is practically confined to the former.

In general, the life history of the parasite in the blood of man is briefly as follows:

The spores are the youngest and smallest forms, which result from the segmentation of the adult parasite. They are rounded or oval protoplasmic bodies, varying in size with the different types of fever and possessing little or no amœboid movement. They remain free in the serum for a short time, but soon attack the red blood corpuscles and become the intra-corpuscular amœboid bodies. This invasion of the blood cells by the immature parasites, while it has not actually been witnessed, may be safely assumed to occur.

As intra-corpuscular bodies they usually occur singly in the blood cell, but sometimes several may be present together. The youngest forms appear as minute colorless specks; as seen in the fresh blood they exhibit amœboid movement and show marked variation in shape, the amount and character of the movement varying with the type of the fever. As these bodies increase in size they become gradually pigmented with dark brown or black specks. The pigment may be scattered through their substance or be concentrated at one or more points, and often shows vibratory movement. The red corpuscles invaded may remain unaltered in appearance or may be either swollen or shrunken. Sometimes, namely in the quotidian and malignant fevers, the parasite passes into a quiescent ring form, showing in this condition a well-defined outer circular margin, the pigment being usually collected in a small clump at one side. These ring forms may again assume amœboid movement. Within the red corpuscle the parasite gradually increases in size until the full adult form is reached, when the parasite loses its amœboid movement more or less completely, has a somewhat rounded form and contains a considerable amount of pigment. The adult parasites may then undergo segmentation, but not all of them do so—many become degenerated and ultimately break down.

In the process of segmentation or sporulation, the pigment becomes collected into a small central mass; and from it, as a center, lines radiate and divide the protoplasm into regular segments, producing a characteristic rosette appearance. The segments or spores thus formed vary in number and size in different types of fever. They are more or less rounded in shape and are set free in the blood plasma. The pigment granules remain apart from the spores, sometimes surrounded by a portion of the substance of the parasite, and are chiefly taken up by leucocytes. The process of segmentation, however, does not occur in all forms of malarial

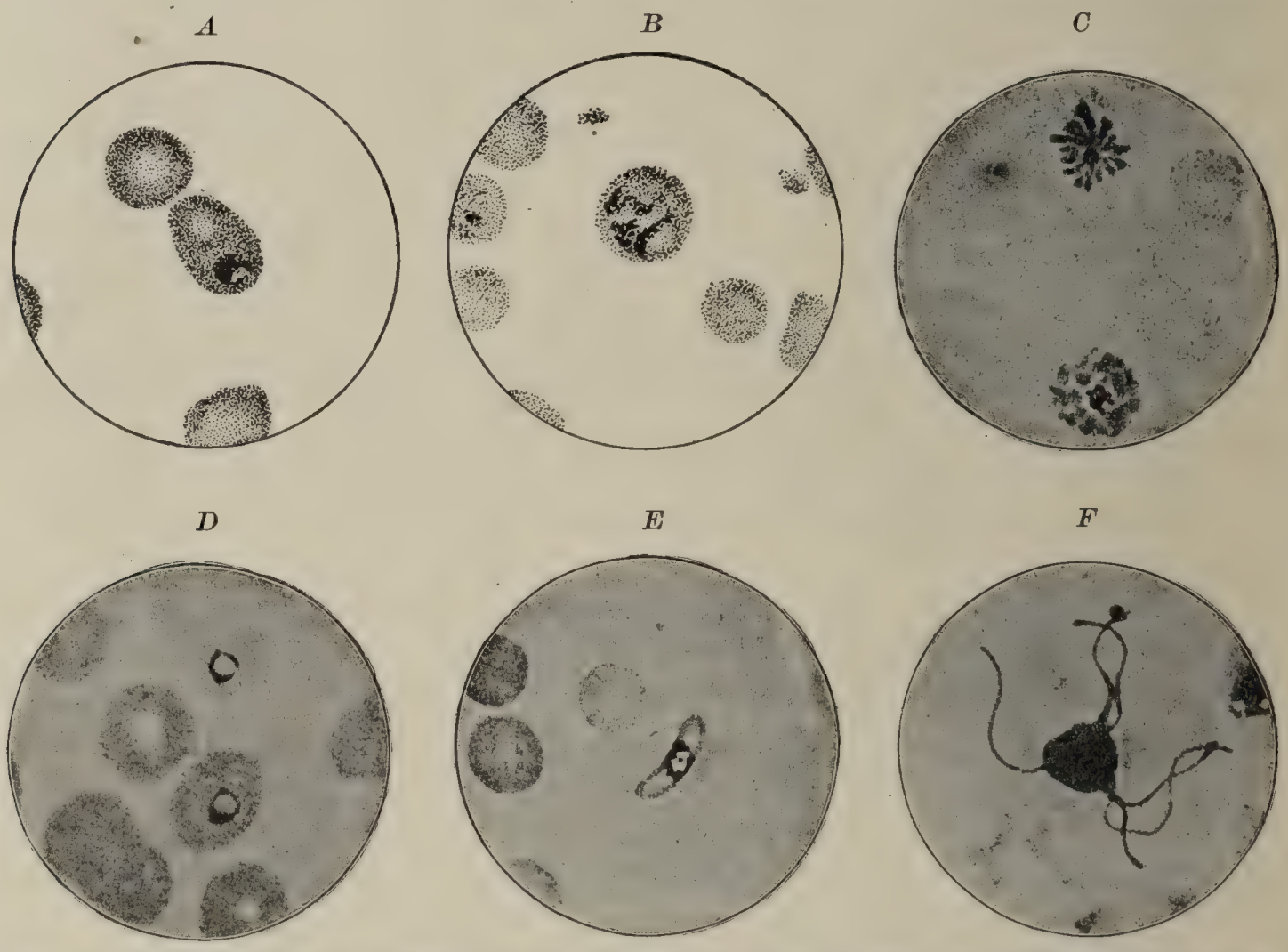


FIG. 340.—Dried Blood-Films Showing Malarial Parasites, Magnified About 1,000 Diameters. *A*, Early intracorpuscular form of tertian parasite; *B*, large intracorpuscular form of same parasite, showing scattered pigment granules, with enlargement of invaded corpuscle; *C*, two members of the rosette series of the same parasite, with early and radiate segmentation; *D*, two ring-forms of the quotidian parasite; *E*, crescentic body; *F*, flagellated organism, derived outside the body from a crescentic form. (After Muir and Ritchie.)

fever in this radiate fashion, but in some it takes place more or less irregularly.

In addition to the forms which appear to constitute stages in this regular cycle of development within the body, there are two others, the crescentic and flagellated organisms.

The first-named organisms are non-amœboid, and are of crescentic or sausage shape. Occasionally a fine curved line is seen joining the extremities on their concave aspect, which probably represents the remains of a red corpuscle. They are colorless and transparent, have a distinct and enclosing membrane, and usually show a small collection of granular pigment about their middle. These crescentic bodies are usually regarded as resulting from the fusion of the intracorpuscular bodies. They are not found in all types of the fever, but occur especially in the quotidian and æstivo-autumnal types, and apparently do not represent a stage in the ordinary

cycle of development. They appear in the blood after the fever has lasted for some time, apparently remain unchanged through attacks of pyrexia, and may persist after the fever has gone—being often present in the cachexia or anæmia following these fevers.

If a drop of blood be examined under the microscope for some time, flagellated organisms may be found. So far as known, these do not occur as such in the circulating blood, but appear only in blood outside the body. They are derived either from the crescents or from the larger pigmented intra-corpuscular bodies. Muir and Ritchie state that in the former case the crescents alter their shape; becoming straight, oval and ultimately spherical. The pigment granules first become arranged as a ring, and afterward show a peculiar vibratory movement that is apparently produced by flagella which have formed within the sphere. When this stage is reached, the flagella, usually three or four though sometimes more, are protruded through the envelope and present a rapid lashing action. The flagella are very delicate filaments with sometimes a slight bulbous swelling at the free extremity. They may afterward become detached and move away with an active independent movement. In the case of their development from the large intra-corpuscular bodies, the pigment shows an agitated movement in the same way, and ultimately the flagella are protruded.

There has been, and is, great diversity of opinion concerning the nature of the crescentic and flagellated bodies. The view most generally accepted is that the former represent a sort of resting form for the life of the malarial organism outside of the body, the first stage of which is the flagellated condition. The view has been advanced that the flagella are really flagellated spores which undergo further change, and that this probably occurs in suctorial insects which have taken up blood containing the parasite; and Ross has found that in the stomach of the mosquito many of the crescents become spherical and develop into flagellated forms.

The principal differentiating characteristics of the different varieties of the parasite may be enumerated as follows:

In the quartan type of infection the parasite passes through its cycle of development in three days, and all the various stages are found in the blood. Only the smaller forms within the red corpuscles show amœboid movements, and these are not of a very active character. The red corpuscles invaded by the parasite do not become decolorized or altered in size, and the pigment granules are somewhat coarse. Typical rosette forms are seen in the process of sporulation, which results in the formation of six to twelve segments or spores. In fresh blood, these spores show a central clear spot which is not seen in the spores of the tertian parasite.

In the tertian form, the cycle of development of the parasite is completed in forty-eight hours. The young forms within the red corpuscles show much more active movement than in the quartan type and give off longer and more slender processes, while the pigment granules are finer. The invaded corpuscles are pale and swollen. Sporulation, resulting in the formation of from fifteen to twenty round spores, takes place by means of a rosette or sunflower formation, the lines of segmentation being at the periphery and a portion remaining around the central collection of pigment.

In the quotidian form, most commonly observed in the tropics, the cycle of development is complete in twenty-four hours. Within the red

corpuscle the parasite is of small size, and even in its adult condition, immediately before sporulation, it does not usually occupy more than a third of the corpuscle. The amœboid forms often pass into the ring form already described. In the course of their development they acquire a very fine dust-like pigment, and in the adult quiescent form the pigment becomes collected into a small dark body. The spores, usually six or eight in number, are formed by irregular segmentation and are very minute. The process of sporulation takes place almost exclusively in the internal organs, and as a rule sporulating forms are not observed in the peripheral blood.

In the malignant or æstivo-autumnal type of the fever the parasite closely resembles that of the quotidian. Its cycle of development, however, apparently occupies forty-eight hours, and the young parasite may be without pigment for twenty-four hours. The malignant parasites do not mature in groups, but independently as it were—parasites in all stages of development being met with in the same specimen. The amœboid activity is manifested even in the adult pigmented forms. In this variety of fever ring forms frequently occur.

In the quotidian and æstivo-autumnal varieties, the red corpuscles invaded have a tendency to shrivel and assume a deeper or coppery tint. When a fatal result occurs, large numbers of parasites, many in process of segmentation, may be found in the brain and internal organs. In some fatal cases, with coma, the cerebral capillaries may appear to be almost filled with them.

Irregular types of fever, sometimes of continued character, may be induced by infection with different generations of the same variety of parasite, or by infection with different varieties.

Though the malarial parasites have not been cultivated on artificial media, the evidence that they are the cause of the disease is conclusive. They are always present in the affection and are found in no condition apart from malaria. Their cycle of development also corresponds in a remarkable manner with the course of the fever, each febrile attack being accompanied by the appearance of a new generation of parasites in the blood. In all probability the fever is produced by toxic bodies set free by the young parasites, but this point is scarcely susceptible of proof. The presence of the parasites in the red blood corpuscles, and the destruction of substance which takes place in the latter, explain the occurrence of the anæmia which so often results; and the subsequent distribution and storage of the altered hæmoglobin, obtained in the destruction of the red corpuscles, explain the pigmentary changes in the various organs. As repeatedly shown by experiment, the disease can be communicated from one person to another by injecting blood containing the parasites; infection occurring most certainly when the injection is intravenous. In such cases there is an incubation period of from seven to fourteen days before the fever occurs; the same type of disease being reproduced as was present in the patient from whom the blood was taken. Recent experiments have demonstrated that the disease may be transmitted from an infected to a healthy individual through the agency of the mosquito. It may be mentioned that in certain affections of birds and reptiles, parasites of somewhat similar character to those in malaria, but of distinct species, occur in the blood. Artificial injection of blood from an infected bird into a healthy

one invariably produces the disease; and the same occurs when mosquitoes which have sucked the blood of diseased birds are allowed to bite healthy ones. In fact, in the latter case, the immature forms of the infecting agent have been directly traced to the salivary glands in these insects.

Manner of Infection.—Since the malarial parasite has not been observed outside the body, and nothing is known concerning its extra-corporeal existence, it is impossible to speak with certainty as to all the modes of its entry into the system. The latter very probably occurs in several ways. It has recently been advanced by some that the disease is transmitted from man to man only by direct inoculation, the mosquito serving as the intermediate host and agent by which infection is brought about. This claim, however, clearly lacks substantiation. It is a matter of common observation that the infecting organism of malaria must be able to multiply indefinitely outside the body independently of man; in fact, malaria is most prevalent where man is not—and where human beings, through the prevalence of this disease, cannot maintain an existence. Therefore this extra-corporeal multiplication must demand something more than a short cycle from man to mosquito and mosquito to man. Where this extra-corporeal life of the malarial parasite is spent has not yet been scientifically demonstrated, but both analogy and common experience point to water as necessary to its existence. As already shown, the parasite in the blood is polymorphous and in the flagellated variety presents a type well fitted to pursue an independent existence. In water it may perhaps assume other and unknown forms capable under certain conditions of directly invading the organism through the walls of the alimentary tract. Certainly this is possible to other somewhat similar forms of life, as in dysentery, and there is much evidence of a practical nature to show that a malarial infection may actually be contracted in this way. Both Manson and Laveran believe that drinking-water in which infected mosquitoes have died may cause the disease, and under such conditions a large number of active flagellated organisms are undoubtedly deposited in the water. Military history is full of instances in which outbreaks of malarial fever have occurred apparently as a result of the use of impure marsh-water, and under circumstances which leave little possibility for infection by other means. As a type of these examples may be mentioned the outbreak of malaria on the ship *Argo*, detailed on page 115, and, like other similar instances, never yet disproved. Further, military history presents many cases in which the rates for malarial fevers have been greatly diminished on the substitution of a pure for an impure water-supply. In our own service, the following instances may be mentioned: Fort Brown, in 1889, had an admission rate for malarial fevers of 1,675.86 per thousand strength, with a rate of 38.58 for constant sickness from this cause. Distilled water from the ice-machine was then provided for the use of the troops, and the rates for 1891 became 325.91 and 8.32 respectively. In 1892 the admission rates had fallen to 16.13 per thousand strength and the constant sickness to .35. The rates for this post have never returned to even a small fraction of what they were before the introduction of distilled water, and Fort Brown has ceased to be regarded as one of the most malarious stations in the army. At Fort Ringgold the admissions for malarial fever, in the year 1885, amounted to 2,304 per thousand strength. Distilled water was supplied for the use of the troops, though its

exclusive use was not compulsory, and in 1889 the rates had fallen to 562 per thousand strength. At this time considerable field service was performed by the troops stationed at Fort Ringgold, and the post surgeon reported his belief that every case of malarial fever could be traced to an infection acquired outside the post. In 1897, the admissions for malarial fever at Fort Ringgold amounted to but 89.42 per thousand strength. In the experience of the writer, the soldiers at Jefferson Barracks were severely affected with malarial fevers; while after the introduction of boiled water a marked reduction in these affections was apparent. Among the officers and their families at this station, who were careful to drink boiled or imported spring-waters only, not a case occurred save in two children who were shown to drink habitually water from impure and unauthorized sources. Later, at Washington Barracks, it was observed that among the men composing two batteries of artillery, who drank unfiltered water, the proportion of malarial cases was four times as great as among the men of the Hospital Corps Company of Instruction, having an average strength of about one hundred and fifty men, who drank only water passed through Berkefeld filters. Such instances as the above may be largely multiplied, and serve to emphasize the fact that, however else the malarial organism may gain access to the system, its entrance by means of the water-supply should never be disregarded by the military sanitarian. Grawitz has recently shown, in connection with the occurrence of malaria through inoculation by mosquitoes, that the disease is most common in the German army during spring, when mosquitoes are not especially active; and he regards a water-supply above reproach as a necessity in preventing malaria. It is true that a number of experiments have been made in the attempt to cause malarial infection by way of the alimentary tract. Healthy persons have been allowed to drink the water from supposedly malarious marshes; enemata of similar waters have been given to other individuals, and even the blood of malarial patients has been drunk by uninfected persons. These experiments were negative in their results. In the absence of positive knowledge that the water contained malarial organisms in the proper stage of development, the first experiments prove nothing; as for the experiment with the infected blood it may well be that in this intra-corporeal stage the parasite has little powers of resistance against the digestive juices. In the light of the instances above quoted, it may fairly be assumed that some important factor present in natural infection was inadvertently omitted from the experiment. On the other hand, besides abundant experimental evidence to the contrary, the theory that malaria is transmitted by water alone is refuted by the fact that men on board ships, anchored off a malarial coast, who may not have been on shore and have used nothing but distilled water, often contract the disease. There is a very general impression that infection can occur through the respiratory tract, though in the absence of knowledge concerning the life of the malarial parasite outside of the body it is evident that this point is not susceptible of absolute proof. Sleeping on the ground, where the emanations of a malarious soil are inhaled during repose, has long been thought to favor the prevalence of the disease among soldiers. It should not be forgotten in this connection, however, that a wind which serves to carry a so-called malarial miasm may also carry insects serving as hosts for malarial parasites, that the period of activity of these insects

is at night and that they are much more numerous near the level of the ground.

As a result of modern investigation, the occurrence of the disease through inoculation by infected mosquitoes has been scientifically demonstrated, and it appears certain that the organism frequently gains access to the blood in this manner. It has not, however, been shown that mosquitoes in a known malarial district harbor this parasite except after sucking the blood of an infected individual; and what part they play, if any, in the origination of the first cases of the disease occurring in individuals penetrating a previously uninhabited region has not as yet been worked out. It may be that the malarial organisms present in water have the power of entering into the malarial mosquito during its period of development in water in the larval stage, and thus some of these insects may be capable of conveying the infection as soon as they arrive at adult form, without necessarily having sucked blood from individuals affected with malaria. That healthy persons may be directly inoculated by mosquitoes which have sucked the blood of a diseased individual there is no doubt. Careful research has shown that, beginning in the stomach as an organism sucked up in the infected blood, the malarial parasite embeds itself in the stomach wall as a round, pigmented body, works its way through the successive coats of the viscus until it comes to lie under the outer layer, and finally bulges into the body cavity. By this time, its bulk has been so greatly increased by the repeated fragmentation of its nucleus and consequent enlargement of its contents, that it has become converted practically into a huge spore-bag full of little rod-like spores. The outer membrane ruptures and the spores are set free in the tissues, to find their way ultimately, in an as yet unexplained manner, into the salivary or venom glands. Here they crowd the acini in myriads, to be discharged into the blood of the human being during the process of biting and there to begin a new stage of development.

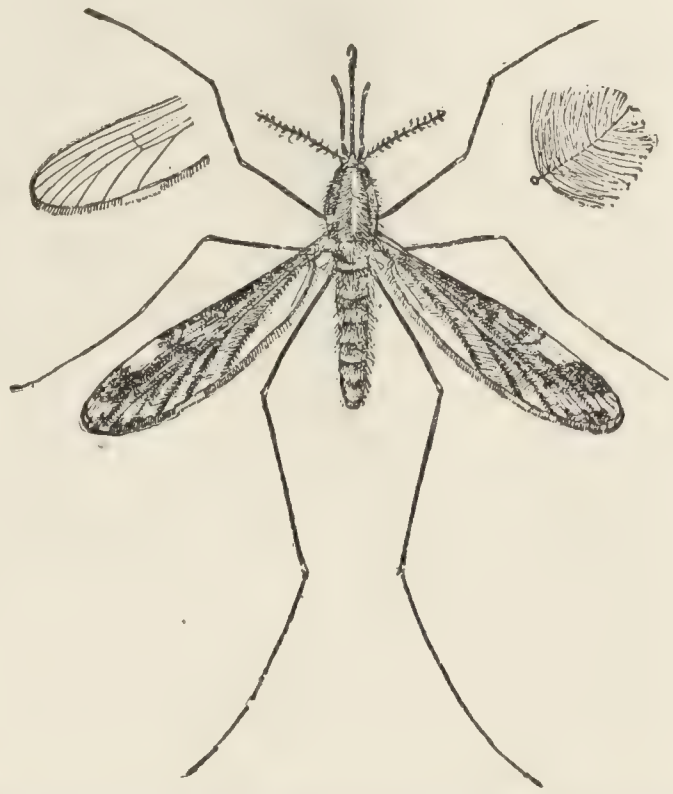


FIG. 341.—Anopheles Punctipennis, Female, with Male Antennæ at Right, and Wing Tip Showing Venation at Left, much enlarged. (After Howard.)

While the mosquito then may transmit a malarial infection, it appears to be equally as definitely proved that only mosquitoes of a certain kind do so, and that many varieties of these insects play no part in the occurrence of malaria in the human being. So far, the genus Anopheles alone has been shown by Ross, of the British army, to transmit the disease; there being of this genus three recognized species native to North America, while a large number of varieties are found in the tropics. The far more common Culex is not at all concerned in the transmission of malaria. The differentiation between the malaria-bearing and the harmless mosquito is not difficult, even to inexperienced eyes. Anopheles has a smaller head

than Culex, while the palpi are much longer than in the latter insect, nearly equalling the length of the proboscis. The front tarsal claw of Culex is toothed, while that of Anopheles is not. Another striking difference is that in Anopheles the wings generally have several large spots along the anterior edge, while in Culex the wings are ordinarily plain. Ross says that this difference holds good in all the mosquitoes seen by him—but there are nevertheless some known species of Anopheles without spotted wings and some known species of Culex with them. The attitudes assumed by these mosquitoes, when sitting on a wall, according to Ross, is characteristic; but Howard found, for this country, that this position holds good only where the mosquito is resting on the ceiling. Anopheles holds its body almost at right angles to the surface on which it sits, its proboscis prolonging the long axis of the body. Culex, on the contrary, carries its body and proboscis parallel to the surface on which it rests. Whatever the attitude assumed by Anopheles, it is all in one line; while that of Culex is invariably angular or hump-backed. In the resting condition, the two insects can therefore be differentiated at a glance. It is said by Howard that the note made by Anopheles is several tones lower than that of Culex.



FIG. 342.—Culex Tæniorhynchus, Female Showing the Short Palpi which Distinguish Culex from Anopheles. Toothed front tarsal claw at right, much enlarged. (After Howard.)

The life history of Anopheles has not yet been entirely worked out, but probably differs to no great extent from that of Culex. The eggs of the latter insect are laid in water, usually in boat-shaped masses, though various forms are assumed. The most common form is that of a pointed ellipse, all the eggs perpendicular, in six to thirteen rows and with three or four to forty eggs in a row. The number of eggs in each mass varies from two hundred to four hundred. As seen from above, the egg-mass is grayish-brown; from below, silvery-white. The eggs hatch, under favorable conditions, in about sixteen hours. The darker colored egg-mass of Anopheles is laid loosely on the surface of the water, each egg lying on its side instead of the end. They are not attached to each other, but naturally float closely together. About forty to one hundred eggs constitute an egg-mass; these hatching in three or four days. Gray was able to raise Anopheles from sun-dried mud and marsh-grass, from which he concludes that the eggs of this species are capable of resisting a considerable amount of drying. In the larval condi-



FIG. 343.—Resting Positions of Culex (at left) and Anopheles (at right). (After Ross.)

tion, the two insects are readily distinguished from each other. The larvæ of Culex float heads downward near the surface of the water but nearly at right angles to it, with the respiratory tube opening at the exact surface. When disturbed, they wriggle down to the bottom of the pool. The larvæ of Anopheles, on the other hand, float flat on the surface like sticks, and when disturbed wriggle on the surface with a backward skating movement — though if much disturbed they may subsequently sink. The larvæ of both Culex and Anopheles are readily drowned when forced to remain below the surface, or when agitation of the water interferes with their supply of air. The color of Anopheles larvæ is dark, nearly black; those of Culex are light gray or faintly yellowish. The larvæ of Culex appear to be found almost entirely in artificial collections of water, as in tubs, pots, broken bottles, cisterns or drains; the larvæ of Anopheles are almost always found in natural collections of water, chiefly rain-water puddles which do not dry up too quickly, which do not contain fish and are not liable to be scoured out by heavy rains. Puddles containing algæ are usually preferred, since the larvæ of Anopheles have been shown to subsist largely upon this vegetable growth.



FIG. 344.—Egg-mass of Culex, greatly enlarged. (After Howard.)



FIG. 345.—Young Larvæ of Culex Pungens, greatly enlarged. (After Howard.)

After a minimum of about seven or eight days for Culex, and about twelve to sixteen days for Anopheles, the larvæ develop into pupæ; these differ from the larvæ in the great swelling of the thoracic segments. In general, the adult Culex issues from the pupa after about two days, Anopheles in five days. The female begins to deposit eggs shortly afterward, giving about ten days as a minimum for the completion of the cycle with Culex, and about twenty-four days for Anopheles—but the rapidity of development of both species varies greatly with the weather. The mosquito is not a short-lived insect, as is generally supposed, but may live for months and habitually hibernates during the winter season. Anopheles is said to bite almost entirely at night, passing the day in a dormant state in which it may be readily caught or destroyed. So far as known, this variety has not been found at an altitude of more than 1,500 feet. Mosquitoes can scarcely fly against the wind, and usually drift with the air-currents. Bignami invites attention to the fact that the precautions taken by natives of malarious countries against infection with this disease are always equally efficacious against the attacks of mosquitoes.



FIG. 346.—Pupa of Culex Pungens, enlarged.

Predisposing Causes.—Excluded from the Arctic zone, malaria appears to increase in frequency and virulence as the equator is approached; but this progression lacks both constancy and uniformity and does not exactly correspond with the isothermal lines. Certain tropical countries,

like Australia and New Caledonia, are free from malaria. It has recently been imported into the island of Réunion by troops returned from the Madagascar expedition, and now, according to Manson, causes one-third of the entire deaths. In general, however, the disease bears a close relationship to warm climates, and of late years a high mortality from malaria has occurred only in the tropics. In this country, the present rates for malarial disease are greatest among troops stationed in the southwest and in the Mississippi basin, although the few posts on the Potomac River are notoriously malarial.

During the Civil War, statistics gathered by the sanitary commission showed the number sick from malaria, per thousand, to be proportioned as follows: In northern posts at a distance from the sea and Great Lakes, 151; in the lake region, 193; at seaboard stations, Delaware capes to Savannah, 370; on the lower Mississippi, 383; in eastern Florida, 520; in the southwest, 747.

Among our troops now stationed in the tropics the rates are high, especially so for those in Cuba. A comparison of the relative prevalence of malaria in the several tropical islands and within the United States, for the year 1899, is as follows:

	Cuba.		Porto Rico.		Pacific Islands.		All Tropical Islands.		United States.	
	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Admissions per 1,000 strength.	Deaths per 1,000 strength.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
Malarial fever, intermittent ..	729.94	....	345.85	....	388.82	....	494.76	....	237.84	....
Malarial fever, remittent.....	322.51	.25	100.62	....	216.45	0.20	246.50	0.21	38.37	0.07
Malarial fever, pernicious	3.94	1.75	1.07	....	1.15	.46	2.03	.84	.50	.12
Malarial cachexia	32.07	.50	11.	....	17.92	.23	22.03	.30	14.17	.02
All malarial infections	1,088.46	2.50	458.64	....	624.37	.89	765.32	1.35	290.88	.21

For the world at large the relative distribution of malarial disease, as affected by climate, is well shown by the following figures for the British army, per thousand strength:

Station.	Year 1898.			Decade 1888–1897.		
	Admissions.	Deaths.	Constantly sick.	Admissions.	Deaths.	Constantly sick.
United Kingdom.....	9.5	....	0.37	6.3	0.01	0.23
Gibraltar.....	4.	....	.25	7.2	.02	.24
Malta.....	152.1	.11	4.17	14.1	.08	.66
Canada	....	....	....	1.3	....	.05
Egypt and Cyprus....	58.4	....	2.19	21.9	.02	.85
Bermuda.....	....	....	....	1.09	....	.08
West Indies	78.5	3.87	4.13	62.2	.06	2.58
South Africa	39.02	.12	1.65	30.2	.08	1.23
Mauritius	380.3	1.22	15.76	579.2	2.76	25.74
Ceylon.....	71.	....	2.28	93.	.87	2.77
China.....	379.2	6.37	16.95	489.6	2.36	14.39
Straits Settlements....	829.9	....	15.17	95.4	.64	3.18
India	434.	.76	15.26	356.9	.71	12.01
West Africa.....	2,027.8	13.89	67.36	1,815.8	52.63	50.26

At certain stations in India, malaria has been at times so prevalent that all drills and parades have had to be discontinued. In former times, the death rate from this disease was often extraordinarily high in the British army. Davy mentions an instance in Ceylon where every white soldier sent to a certain station contracted malarial fever; and states that out of a total strength of 254 men there were 205 deaths from this affection.

Next to climate, the influence of season appears to be of the most importance; the rates for troops throughout the United States attaining the maximum in September and the minimum in February—as is well shown in the following diagram.

The relationship between malarial infection and marshy and swampy localities has long been recognized. Malaria, however, has been known

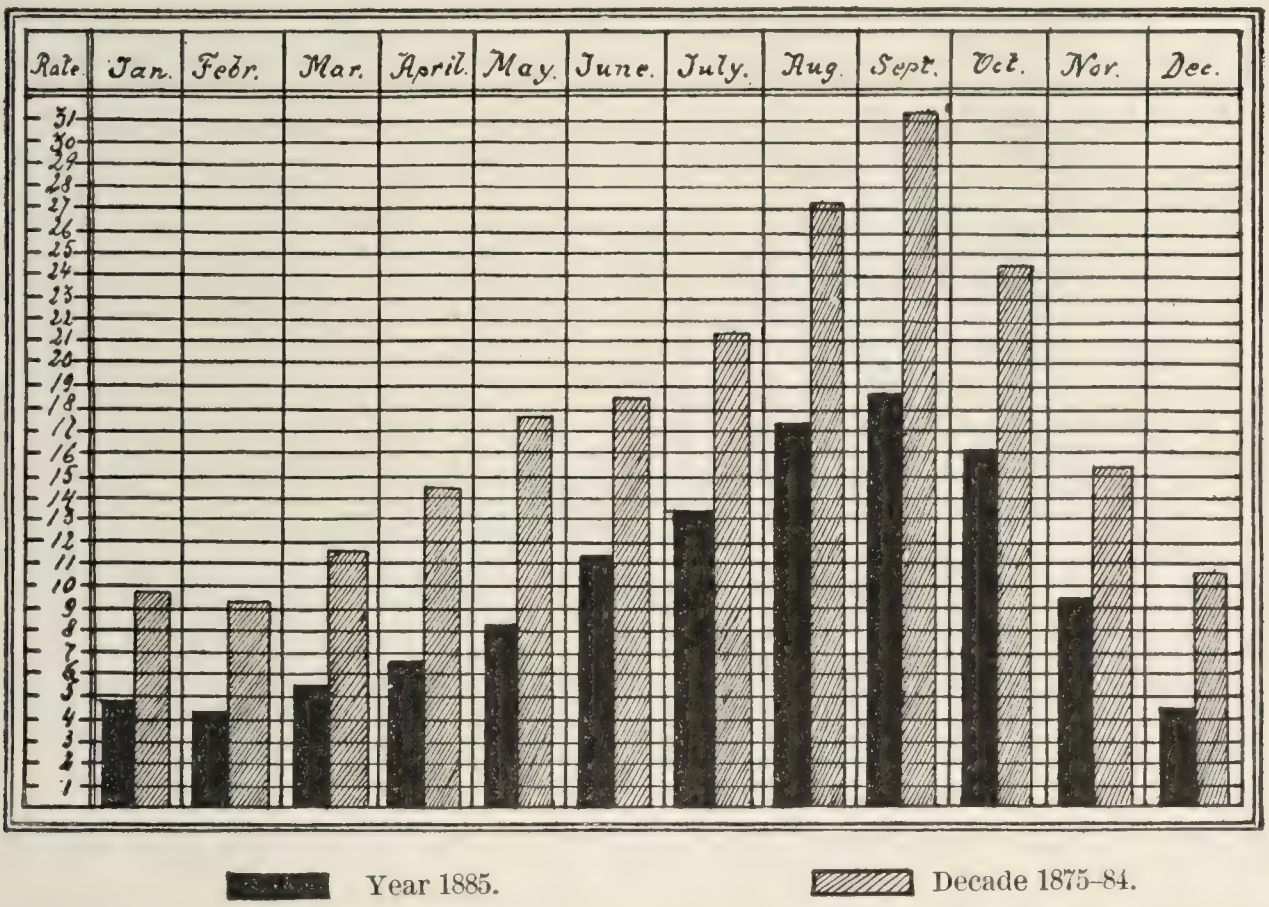


FIG. 347.—Diagram Illustrating the Distribution of Cases of Malarial Fever by Months, per Thousand Strength, Occurring in the United States Army. Also showing the constant reduction of malarial infections.

to occur in localities not especially marshy and, on the other hand, to be absent from regions wet and swampy. Of this latter fact the city of Mexico, surrounded by lakes and marshes, furnishes a conspicuous example. It must be admitted, however, that malarial disease is much more frequent on marshy coasts and low, humid plains than on higher ground where drainage of the soil is more complete, and a certain amount of moisture in the soil is appearently essential to the development of the malarial virus. Marshes that are alternately flooded and partially drained of water offer conditions most favorable to the development of malaria. Under such conditions the profusion of rank vegetation, together with decaying organic matter, does much to favor it; though it may sometimes occur on barren, sandy soils with high ground-water, particularly if the soil be organically contaminated. The broad, alluvial deltas of great rivers and the valleys of smaller streams are, in warm climates, usually malarious. The breaking or clearing of new lands, in malarious regions, usually results in an outbreak of the disease in the immediate vicinity; but by prolonged culti-

vation, malaria becomes less frequent and severe and may finally disappear. The geological character of a soil appears to play a somewhat important part in the production of the virus. An impervious surface-soil, which does not readily become saturated with moisture but favors the rapid shedding of storm water, is not regarded as favorable to the development of the disease. A permeable, shallow surface-soil lying over an impervious stratum may favor the development of malaria under conditions of very moderate rain-fall. In general, excessive or prolonged rain-fall favors the occurrence of the disease. At high altitudes, the disease disappears or becomes infrequent; in the tropics it is said that a height of as much as 2,000 feet is usually necessary to secure a fair immunity. In the Philippines, however, a very virulent type of malaria appears to prevail in the more mountainous districts.

While troops may be attacked by malaria when on board ship, this is now rarely the case in practice. During the disastrous expedition of the French in Madagascar, in 1895, it is said that not a single fatal case of malaria occurred on board the thirty vessels constantly maintained off the coast, and many striking instances to the same effect have been recorded. There is a general conviction that the malarious virus may be carried by winds. In malarious regions near the coast, the land breezes, especially if they traverse neighboring marshes, appear to favor the disease, while sea breezes do not. Many localities which might be otherwise highly suspicious, but which are continually wind-swept, are often free from the affection. Under ordinary circumstances, the virus of malaria does not usually ascend very high above the level of the ground; troops on the upper floors of barracks may largely escape the disease where those on the lower floors contract it. There is evidence, however, that the malarial infection may be carried to high altitudes by strong winds blowing up narrow unhealthful valleys. The recognition of the mosquito as an agent for the transmission of this disease has done much to explain the influence of air-currents in this respect; and the same may also be said with regard to the supposedly baneful influence of night air, since the malarial mosquito is not active during daylight. Davy says of certain British troops in Ceylon that they were largely exempt from malarial fever as long as they were employed by day only; so soon as they were employed more by night than by day, particularly in convoys and the relieving of posts, fever became very prevalent and destructive. Of one company seventy strong, which was forced to sleep out in the jungle for a single night, he states that every man contracted fever and many died. Lemure gives an instance of a garrison of fifty French soldiers in Madagascar, of which at the end of two months six were dead, twelve had been invalided home and all the remainder presented malarial infections. At the same time, the sanitary condition was good among a body of marines at the same station and performing the same duty, but who returned to their ship at night to sleep.

Experience shows that negroes, native to and living in a malarious country, possess an undoubted immunity to malarial fevers. This immunity, however, is lost to a considerable extent after long residence in a non-malarious climate, and does not exist to any very great extent among negroes native to regions where this disease does not commonly prevail. The difference in respect to susceptibility between white strangers and native blacks

is, however, great. In the British expedition up the Niger, of 145 whites and 158 negroes, there were 130 cases of fever with 40 deaths among the whites, while there occurred among the negroes but 11 mild cases, and these only in individuals who had passed several years in England. In West Africa, Great Britain has found it scarcely possible to retain white soldiers, and the garrisons are composed almost wholly of native negroes. For the decade 1888–97, the admission rates for malaria in West Africa was 1,815.8 for the whites, in spite of special precautions taken to prevent their infection, and but 990.9 among the negro troops. The death rate from this affection among the whites and negroes was 52.63 among the former, and but 5.75 among the latter. In our own service, the rates for malaria during time of peace are invariably higher among the whites than in the colored troops, although the difference is but slight as compared with the figures just given. During the war with Spain, the figures were reversed and the rates for colored troops were much higher than for the

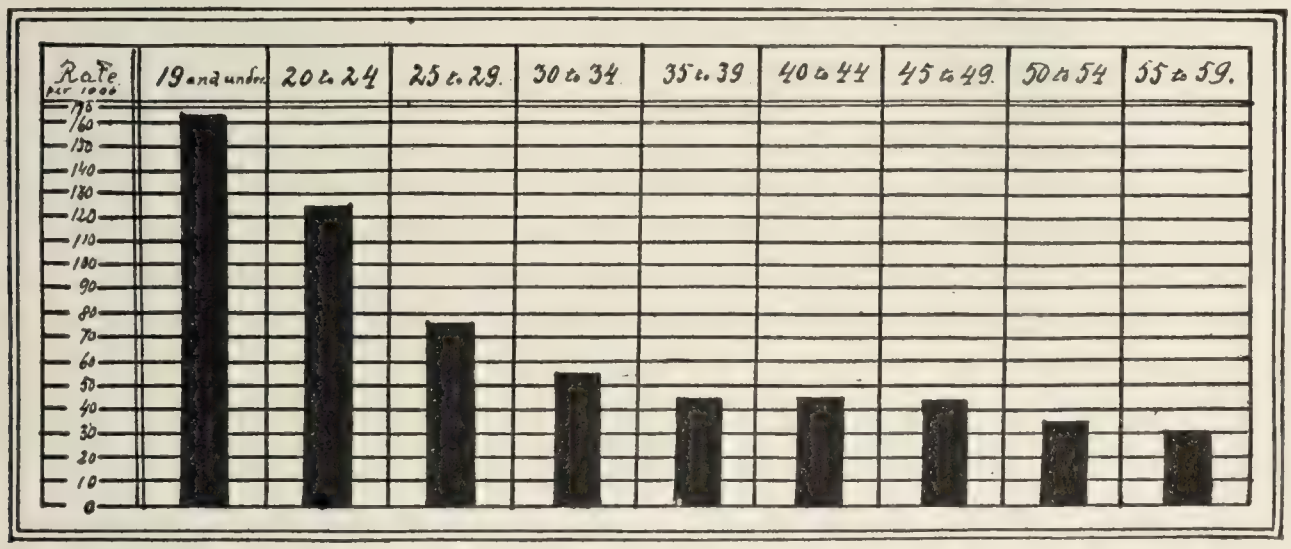


FIG. 348.—Admissions, per Thousand of each class, for Malarial Fevers in the United States Army, Arranged According to Age, during the Seven Years 1890–96.

white. This, however, is readily to be explained by the fact that the negro troops were nearly all engaged in the tropics, while many of the white soldiers, especially those in the artillery and cavalry, were not moved from the United States, or in some cases from their usual posts. Among our white soldiers, the native-born American appears to be slightly more susceptible to malarial infection than are the men of foreign birth; thus, for the seven years 1890–96, the admissions for malaria, per thousand strength, amounted to 84.24 for American-born whites; 81.94 for soldiers of Irish birth and 74.67 for those of German nativity.

As is the case with nearly all other diseases, age is a factor of great importance in predisposing to malarial infection, as is conclusively shown in the preceding diagram.

During time of peace, for the seven years 1890–96, the admission rates for malarial disease, according to the branch of service, were proportioned as follows:

	Per 1,000 of each class.		Per 1,000 of each class.
Artillery	163.24	Ordnance	60.91
Engineers	130.66	Medical department	55.31
Cavalry	110.79	Infantry	46.28

Many of the sea-coast fortifications garrisoned by artillery are notably

malarious, as is the station of the engineer troops. The greater prevalence of the disease in the cavalry as compared with infantry is to be explained by the greater proportion of field service performed by the former.

Malarial fevers are much more common among soldiers than officers; thus for the seven years 1890–96, the admissions in our army, per thousand strength, were 81.74 for enlisted men and 40.20 for officers.

Common experience shows that a considerable number of individuals, exposed to the malarial poison, escape infection. While this may be due to a racial insusceptibility, as already mentioned, the strongest predisposing element in the development of disease, to which malaria is no exception, is a lowering of vital resistance through unsanitary surroundings, bad food, exhaustion or exposure. Among these factors, physical exhaustion is not of the least importance—and in this connection Coustan calls attention to the fact that in the Madagascar expedition the proportion of deaths among the French officers was 1:16.6, while among the soldiers, who were exhausted by the carrying of heavy burdens and long marching, the proportion was 3:5. Under-fed or fasting troops are very susceptible to malarial influences, and early morning drills before breakfast, or late guard duty, are especially favoring factors. Exposure to heat undoubtedly exerts a predisposing influence to malarial infection, and the same is commonly believed to be the case with respect to alcoholic excesses.

The acclimation of troops in a malarious country cannot be counted upon, military experience showing that the mortality from this disease increases with the length of the sojourn. One attack of malaria, unlike the eruptive fevers, predisposes to another; and it is a rule in the French service to select for expeditions in the tropics only such as have not previously suffered from the disease.

After residence in a malarious country, with or without symptoms denoting an existing malarial infection, the disease often appears in a sharp or persistent form after removal to a region in which malaria does not originate. This has commonly been observed in recruits sent from malarious stations to healthful districts in the west, and was particularly evident among our troops returned from Santiago.

Prophylaxis.—This depends upon the application of both special and general measures of prevention, and of these the former are probably of the most importance. In the avoidance of malarial infection by inoculation, it is evident that troops should be shielded against the attacks of insects; and further, that the insects should be destroyed. From the nature of military service, it is obvious that soldiers cannot at all times avoid being bitten by mosquitoes, especially in the field; much may, however, be accomplished to this end, and the less the number of bites the fewer are the chances of infection. In garrison, all doors and windows should be provided with screens and mosquito bars should be attached to all beds. The nets should be square, should be hung inside a framework, and should be tucked carefully under the mattress all around and stretched tightly better to allow the passage of air. The mesh may be fairly coarse, but must be free from rents. Care should be taken to destroy all mosquitoes within the netting before going to sleep; this being best accomplished by having an assistant hold a light at one corner outside the net, toward which the insects fly and are readily despatched. In the field, in

malarious districts, soldiers should be furnished with squares of mosquito net or head-nets for use at night. The weight need not amount to more than a couple of ounces, and such a protection would conduce much to comfort and health and amply repay its carriage. In camps, smudges made of green boughs lighted to windward, so that the smoke blows over the men, are often of great value; for this purpose the eucalyptus boughs are said to be especially valuable, the mosquito having an especial antipathy to this tree. Any essential oil, as oil of pennyroyal, smeared in small quantity over the exposed surface or dropped on the pillow, may keep off these insects, but since these substances are volatile they require to be frequently renewed. In Italy, slices of onions are often used for the same purpose. Mosquitoes which have gained access to barracks or quarters may be destroyed mechanically, or by the fumes from burning pyrethrum powder, tobacco or even green wood. The vapor of turpentine also kills them; and an excellent way of destroying those resting on the ceiling is to raise up under them cups containing a little mineral oil, into which the stupefied insects fall on inhaling the vapor. Leggings are an excellent protection for the ankles against these insects, but gloves or head-nets can rarely be worn on the march. Since patients suffering from malaria are capable of directly infecting others through the agency of mosquitoes, they should always be treated under mosquito-netting; and this precaution should be continued for weeks after the actual fever has disappeared, certainly so long as repeated microscopical examination shows the presence of the malarial organism in the blood.

Where mosquitoes are present in barracks, suitable conditions for their development are usually found close by, as these insects rarely travel any great distance. In the case of Anopheles, these breeding-places are small stagnant pools. Where these cannot be filled up or drained, recourse should habitually be had to culicides for the destruction of the larvæ and pupæ. For this purpose, the substance most available for military use is mineral oil; this being sprinkled over the surface of the water, as with a broom, until a fine film is produced which destroys the larvæ by cutting off the supply of air and choking their air-tubes. The adult insects, which subsequently alight on the surface to deposit their eggs, are also destroyed. This film must spread over the entire surface of the water and should have a permanency of at least three days, to kill the larvæ as they are hatched from the eggs. The quantity of oil required naturally varies with the conditions met with; but for small still pools probably one ounce of kerosene to each fifteen square feet of water-surface is sufficient. Surface vegetation, sometimes very abundant, may often obstruct the mechanical action of the oil, and in waters even very slightly running it must be frequently or continuously renewed. Petroleum, also, has the disadvantage of evaporating somewhat rapidly in warm weather. Strong infusions of tobacco are fatal to the larvæ; and they are destroyed by powdered chrysanthemum flowers, as now found in commercial insect powders, in the proportion of three parts in the million. Recently Celli and Casagrandi have shown that gallol, in the proportion of seven parts to the million, is the most certain and effective agent in destroying the larvæ, and possesses the additional advantage of great permanency. Whatever be the special method of destruction employed, the life history of the mosquito shows

that it should be repeated at intervals of about ten days. The introduction of small fish or minnows into fishless breeding-places of the mosquito is of great importance, as these feed greedily upon the larvæ and soon exterminate them.

General measures of prophylaxis have been shown by experience to be of value in the prevention of malaria. It is not advisable to take an army into a malarious country during the fever season, and in localities where the disease prevails to great extent it is well to retire to high ground during the malarial period, as is done by the English in India and Jamaica and by the French in Guadeloupe. In locating a camp or post in a malarious district, special care should be taken in the selection of a salubrious site. In general, the appearance of the natives will give some knowledge as to the relative prevalence of this disease among them.

The abandonment of highly malarious posts, in time of peace, is much to be desired and can usually be accomplished. The retention of unhealthful stations is at the expense of unnecessary suffering, and in the past many thousands of lives have been uselessly sacrificed to tenacity of position. With marching troops, zones of malarious country should be avoided or passed over as quickly as possible. The abolition of marshes by flooding or drainage, and the removal of adjacent shrubbery and rank vegetation are great prophylactic measures in reducing malaria in a garrison. Plants of rapid growth should be cultivated for the assistance which they give in removing moisture from the soil. For this purpose the eucalpytus, castor-oil plant and sunflower appear to be most satisfactory; these not only drying the ground but being shunned by mosquitoes. Subsoil drainage is often of great value, but this can rarely be thoroughly carried out in the military service. Barracks for hot, malarious climates should be raised on piers, be cemented underneath and be of two stories. All water used for drinking purposes should be sterilized by heat. Food should be abundant and nutritious. Distributions of hot coffee for those on guard at night, or who are engaged in arduous labor, are often of value. The use of quinine as a prophylactic, where troops are temporarily exposed to marked malarial influences, is of great importance, as has been repeatedly demonstrated. Not only are the cases of malarial infection greatly decreased in number by its use, but the character of the cases which occur is favorably modified. In general, a dose of five grains once daily will be sufficient, preferably taken shortly before any unusual exposure is anticipated. In a malarious country, the routine issue of quinine after anything lowering the resistive power, such as a forced march, wetting or lack of food, has much to commend it. In the Italian army, arsenious acid has been tried in the prevention of malaria, but with little satisfaction. Exposure, particularly to heat and night air, and over-exertion should be avoided. If disturbance of the soil be necessary, as little ground as possible should be disturbed at one time and the work should not be begun too early in the day. As few men as practicable should be employed in the work, and only such as have not had a previous malarial infection; and the same applies to the composition of expeditionary forces into fever districts.

Measles.

Occurrence.—Among troops, measles is of frequent occurrence. Under certain circumstances, when developed under conditions of want, hardship, exposure and bad sanitation—and especially when associated with a scorbutic taint—the disease may assume an extremely severe and fatal character. Formerly, the occurrence of the hemorrhagic form of measles was not infrequent among troops and was much dreaded. The exposure in the treatment of measles cases in tent-hospitals, often unavoidable, does much to develop secondary bronchitis and pneumonia; and to these latter causes is to be attributed, also, much of the gravity which the disease has assumed when prevailing among troops during the existence of hostilities. In garrison, the mortality from this disease is usually small; for the period of peace 1885–94, in our army, the death rate was but one one-hundred-and-tenth of the rate given by the Registrar-General for the total population of England and Wales, for the same cause, during the same period. From 1832 to 1859, however, according to Rosse, measles was the cause of 2.7 per cent. of deaths from all causes occurring in the garrison of Paris. During the Civil War there were, in the Union forces, 75,177 cases with 5,174 deaths; the admissions per thousand strength, during this period, amounting to 31.72 and the deaths to 2.02. Among the Confederate troops, Eve states that measles prevailed to such an extent that whole companies, battalions and even regiments, under organization, had to be disbanded and the men sent home. During the siege of Metz, measles was extremely prevalent and fatal in the garrison. In our army, for the period 1868–98, there occurred a total of 3,733 cases with 15 deaths, giving an admission rate, per thousand strength, of 4.50 and a death rate of .017.

The disease appears to be relatively more prevalent now than formerly among our troops, the rates being as follows:

Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1868–84	1.88	0.004
1885–94	4.85	.004
1895–98	13.72	.09

The expansion of the army by a large number of susceptible recruits at the outbreak of the war with Spain, and their aggregation in large camps where the communication of the disease was favored, did much to raise the rates for admissions and mortality during the last period given above, the admissions for measles during the year 1898 being 25.09 per thousand strength, and the deaths amounting to .26 per thousand; while for the previous year of peace, 1897, the admission rate was only .82 per thousand, with no deaths. In the German army, the rates of admission for measles, per thousand strength, for varying periods, have been uniformly low, as follows:

1881–82 to 1885–86	1.4
1886–87 to 1890–91	1.5
1891–92 to 1895–96	0.83
Year 1896–97	1.1

In the French army, the rate of admission per thousand strength, for the five years 1890–94, was 9.71. Coustan believes that the system prevailing in the French army, of turning into a common magazine certain articles of the equipment worn annually for a few weeks during the field manœuvers, greatly favors the dissemination of the infection of measles and hence partially explains the high rates to be observed in that army. In the Austrian service, for the year 1897, the admission rate was only 8 per thousand, but the proportionate mortality was high, .02.

Colored troops appear to be less susceptible to measles than are whites, but certain mild cases are more liable to escape recognition in the former class; the rates of admission in our army for measles, in 1898, were 25.91 per thousand whites and 14.42 for colored troops. During the Civil War, however, the rates were 30.41 for white, and 46.65 for colored troops—this excess as regards the negroes being apparently due to lessened efforts for the control of the disease among them. The disease occurs far more frequently among recruits than old soldiers; in the Civil War, the number of cases depending upon the proportion of susceptible individuals and occurring particularly in country-bred recruits. For the French army, Coustan gives the following figures with respect to length of service as influencing the occurrence of measles:

Year.	Less than one year service, admissions per 1,000 strength.	More than one year service, admissions per 1,000 strength.
1891	23.63	12.69
1892	9.62	4.04
1893	11.98	6.08
1894	14.80	7.91

In our own service, measles prevails to by far the greatest extent at the recruiting depots; the recruits at Columbus Barracks, in 1892, furnishing more than half the cases occurring in the entire army.

The disease, in this country, ordinarily occurs most frequently during cold weather, when ventilation is comparatively restricted and the opportunity for infection is most favorable. During 1898, when the proportionate number of recruits was great, the rate of admission was by far the highest during June and July—thus showing the greater importance of length of service as compared with season in influencing the prevalence of this disease. During the same year, the admission rate was 19.82 per thousand soldiers stationed within the United States, while there was a total rate of 48.25 for the troops serving in the West Indies and the islands of the Pacific. The case mortality of measles, as already noted, is capable of varying within very wide limits, ranging from as little as 1 or 2 per cent. in some outbreaks to 40 or 50 per cent. in others. "In Paris, during the siege (January, 1871), out of 215 of the Garde Mobile who took measles, 86, or 40 per cent., died; and the mortality reached very nearly the same figures among the French troops who returned to Paris after the Italian War, 40 out of 129 cases dying in one hospital whose sanitary condition was bad." As in typhus fever, the concentration of a large number of measles cases, with deficient ventilation, appears unfavorably to affect the prognosis and course of the disease.

Infection and Dissemination.—From analogy, it may be assumed

that the cause of measles is a specific micro-organism, but as yet its special nature has not been determined. The infection is presumably given off by the breath and mucus from the catarrhal surfaces, also by exfoliated epidermis. The poison is undoubtedly capable of being air-borne, and tends to cling to fomites and to remain in ill-ventilated spaces. The infectious agent is very tenacious of life; and where it once fairly establishes itself, as is apparently the case at present at Columbus Barracks, annual epidemics are the rule. There is no evidence that the disease is transmissible by water or food; infection probably always occurs through inhalation. The disease is not infrequently introduced among troops in garrison by children. The incubation period varies from eight to twenty days, the usual limit being about eleven days. The infectivity begins with the earliest symptoms; it is greatest while the catarrh and rash are present, and probably extends well into convalescence. As a general rule, infectiousness is over by the end of the fourth week, provided that cough and desquamation have ceased. One attack of measles usually confers immunity as regards future infections.

Prophylaxis.—In view of the fact that measles is mild under favorable conditions and may be very fatal when the patients are exposed to inclemencies of weather, it was seriously advised, during the Civil War, to infect all susceptible recruits with this disease on their enlistment and thus insure their immunity before sending them to join their regiments in the field. In civil life, vigorous efforts are rarely made to prevent the spread of measles, but in the military service the opposite should be the case; bearing in mind that this disease is never devoid of danger and, particularly in the field, may at any time assume a grave character. Further, it causes the loss of a considerable amount of service by troops to which the state is entitled. The efforts toward prevention include the isolation of the sick and the disinfection of all contaminated clothing, bedding and surroundings. The discharges should be disinfected, particularly those from the mouth and eyes. For receiving the latter, soft rags should be employed and these burned after use. As far as the patient is concerned, Cameron concludes that "so far as figures are of value, ample air-space, free draft, freedom from overcrowding and from effluvium nuisances conduce most to recovery."

In the spring of 1898 the writer began some investigations with regard to the production of an artificial immunity against measles. The experiments were abruptly interrupted by field service, but appeared to be distinctly favorable so far as carried out. The method employed consisted in the subcutaneous injection of blood-serum obtained from convalescents from measles by means of cantharidal blisters. The injections were made in children living in an infected garrison, about 5 c.c. being administered in three doses at intervals of about forty-eight hours. None of the cases so inoculated contracted the disease, while a considerable proportion of the susceptible and uninoculated children became infected.

Mumps.

Mumps occurs very frequently among soldiers, especially young soldiers, but its mortality is practically *nil* and it becomes of importance merely from the temporary disability for military service which it causes.

In a total of 3,122 cases of mumps occurring in the United States army for the thirty-one years 1868–98, inclusive, there was not a single death which could be attributed to this affection. The admission rate for mumps during the period 1868–84 was 2.99 per thousand strength; for 1885–94 it was 5.08, and for 1895–98 it was 4.05. The rate of admissions for the entire period, 1868–98 inclusive, was 3.76 per thousand.

In the military service, mumps usually prevails in well-defined epidemics, and a large proportion of the cases occur in recruits. The aggregation of such young men at certain stations, for purposes of instruction, is very favorable to the appearance of this disease; and in 1894, out of 337 cases of mumps occurring in the army, there were 119 cases at the two recruiting depots of Columbus Barracks and Jefferson Barracks, while in the previous year, out of a total of 149 cases, 43 cases occurred at the first named station. Orchitis and atrophy of the testicle are very common among soldiers affected with mumps, being present in about one-third of the cases. Coustan states that in an epidemic among French soldiers, in 1891, every man attacked by mumps developed orchitis; while Laveran found it 211 times in 699 cases. The infectious agent is supposed to be given off by the breath and the secretions of the mouth, but as yet no specific organism has been isolated. It is not conspicuously disseminated by means of fomites; in garrison, it frequently appears to be introduced from outside by children. The period of incubation is reckoned as from fourteen to twenty-five days, and the case is regarded as infectious while there is any inflammation or tenderness of the salivary glands. Sanitary precautions consist in the isolation of the patient and the disinfection of his clothing and equipment. Beyond the cleansing and disinfection of the cuspidors in the squad room, no further preventive measures, in view of the comparative triviality of the affection, will usually be necessary. Among soldiers, outbreaks of mumps not infrequently occur in close association with measles, but this apparent relationship is probably to be regarded as accidental. The disease is most common during the colder weather.

Plague.

Occurrence.—With the recent appearance of plague in the Philippine and Hawaiian Islands, this disease at once assumes a practical importance in relation to our military service. Plague has not, in recent years, figured to any extent among the diseases affecting troops of any nationality; but numerous military epidemics have been reported in the past. The destruction of the Assyrian army, recorded in II Kings, was probably due to plague; and the disease described by Thucydides as affecting the 200,000 men immured in Athens, in the Peloponnesian War, presented the symptoms of the catarrhal form of this disease. Plague ravaged the armies of the Crusaders, and it is said that in the first crusade no less than 50,000 men perished from this disease before Antioch. The soldiers of Cromwell died of plague as well as typhus; and it prevailed among both French and English during the first occupation of Egypt. In 1816 it was imported into Arabia by the Egyptian army, and has since prevailed there endemically. A military epidemic of this disease is said to have occurred as late as 1828, in the Russian expedition against Turkey. Plague prevails endemically in

China, western Asia, northern Africa, and perhaps India; from which points it has from time to time extended. It has recently been carried to Uruguay, Brazil, Mexico, and, in this country, California. It has also been lately transported to New Zealand, Madagascar, South Africa, New Guinea and a number of islands in the Pacific, among which are our own possessions.

Cause.—Plague is caused by a specific bacillus; found in large numbers in the suppurating glands and to a less extent in the blood. Under these conditions it appears as a small oval rod, somewhat smaller than the typhoid bacillus. The ends are rounded, and in stained preparations a portion is sometimes left uncolored in the middle of the bacillus. Staining is readily accomplished by any of the ordinary aniline dyes. The bacillus is decolorized by Gram's method of staining. In the tissues, the bacilli are found scattered among the cells, for the most part lying singly, though pairs are also seen; but in cultures, especially in fluids, they have a tendency to grow in chains. They are not spore-forming, are actively motile and have been shown to possess flagella, which, however, stain with difficulty. The bacillus is readily cultivated on ordinary media at body temperature. It grows on solidified blood serum, without causing liquefaction, as a yellowish-gray deposit; the colonies appearing as circular discs having a smooth shining surface. When cultures on agar, with a dry surface and slightly alkaline reaction, are incubated at body temperature, involution forms rapidly appear. These are seen on the third day and present the most varied forms; Haffkine states that some reach a size many times that of the healthy bacillus. In bouillon, the growth usually forms a slightly granular or powdery deposit at the bottom and sides of the flask. If the bouillon be kept absolutely at rest, flakes form at the surface, and growth extends downward from these, forming the so-called "stalactites." These columns of growth are easily broken up when the flask is moved, and fall to the bottom as a powdery deposit. Haffkine regards this feature, together with the involution forms on dry agar, as of great importance in the recognition of the organism. In its powers of resistance, the plague bacillus corresponds to the other spore-free bacilli and is readily killed by heat. It resists drying for four days at the longest, and exposure to direct sunlight for three or four hours destroys it. When cultivated outside the body, the bacillus rapidly loses its virulence.



FIG. 349.—Bacilli of Bubonic Plague in Pus from Bubo. (After Abbott.)

Predisposing Causes.—The mortality from bubonic plague varies with different epidemics. Race exerts a marked influence both on the occurrence of the disease and the mortality. Of late years, whites in the Orient have rarely contracted the disease; and, when so affected, the mortality is low. In the epidemic at Hong-Kong, in 1894, Lawson states that the percentage mortality of those attacked was as follows: Europeans, 18.2; Japanese, 60.0; Malays, 100.0; Chinese, 93.4. The disease is preeminently favored by want, privation and lack of proper sanitation. Haffkine places the average period of incubation of the disease at about six days, but this is exceeded in many instances.

Propagation and Dissemination.—Plague has developed so uniformly in unclean places that filth is regarded as an essential factor in its propagation and spread. Almost without exception, plague-centers have been characterized by a soil polluted by decomposing animal material and by the overcrowding of a dirty and insufficiently nourished population. Plague bacilli have been isolated from the dust of infected houses, and the pest is generally regarded as a ground rather than a water disease. In the epidemic in Hong-Kong, in 1894, Lawson was impressed with the part which dust and dirt played in the transmission of the infection. When the microbe is removed from a soil saturated with organic filth, it appears to lose much of its virulence. The bacillus has been shown to survive for two weeks in water, and hence the supply used for drinking and purposes of cleanliness should be pure. While the disease appears at times to be transmissible by air, this is possible only within a small radius; there is considerable evidence to show that it may be transmitted by means of food. The disease may be spread by means of clothing and other articles which have been used by plague patients; but is most often disseminated by human intercourse. Aoyama believes that the specific bacillus gains entrance to the body largely through skin wounds, and much less frequently than has been supposed by way of the respiratory and alimentary tracts. The fact that there may be no local manifestations at the lesion of entrance is important.

A large number of animals, particularly rats, mice and small rodents, are susceptible to the disease. Rats die in great numbers in pest-smitten districts, sometimes before the affection appears in human beings. There can be little doubt that these animals play a most important part in distributing the disease over wide areas from a focus of infection, when it has once broken out. This has been abundantly proved in the case of Bombay, where observation has shown that the emigration of plague-infected rats to districts comparatively free from the disease has been attended by an extensive outbreak in the latter places. In addition to the pus of suppurating buboes and the blood, the bacilli have also been found in the sputum, urine and fæces of both men and animals. Further, it has been shown that the flea is frequently an agent by which inoculation is made from affected to sound animals. Pest bacilli have been found in the stomach contents of these insects, and fleas taken from plague-afflicted rats have been made the means of communicating the disease to healthy animals. Nuttall, Yersin and Ogata have found pest bacilli in large numbers in the bodies of flies in an infected locality. Even after forty-eight hours' retention in a clean receptacle without infected food, infected flies were found to be full of virulent bacilli. The experiments of Nuttall and Ogata are to the effect that ants and mosquitoes may be the carriers of this disease; the latter producing infection by direct inoculation. Bedbugs, however, appear to digest and destroy the bacilli. From the facts stated with regard to the powers of comparatively rapid multiplication of the plague bacillus, its wide dissemination by the excreta and by animals and insects, it may be understood how extensively soil and habitation may become infected and how correspondingly difficult it may be to arrest the ravages of the disease. The important part played by the infection of a locality is strikingly shown by the rapid fall in the number of cases when an infected site is abandoned and the inhabitants are placed in tents.

Prophylaxis.—The most important safeguards against the threatened development of plague are cleanliness of person and surroundings, good drainage, free ventilation, a proper standard of nutrition and a war of extermination against rats and mice. In addition, the prophylactic use of Haffkine's anti-plague serum is of great importance. When the disease makes its appearance, the sick should be at once isolated in tent hospitals, and all who have come in close contact with them, or have been exposed to the same conditions, should be quarantined and kept under observation for ten days. The belongings and surroundings of the patient should be carefully disinfected. The sputum, urine, fæces and dressings from suppurating buboes should be burned. Only healthy persons, free from abrasions, sores or ulcers, should be allowed near the sick; and such should be required to maintain scrupulous personal cleanliness and take a disinfectant bath at least once daily. Troops should receive abundant food and pure water; and the necessity for personal cleanliness and the frequent change of clothing impressed upon them. The use of well-fitting shoes, together with great care of the feet, is necessary; since there is considerable evidence to show that inoculation usually takes place in the lower extremities. Soldiers should avoid infected districts, except under competent authority.

If proper care be taken, the liability of white troops to contract this disease appears to be slight. At Hong-Kong, in 1894, of 300 British soldiers who volunteered to assist in the sanitary policing of infected houses, but 10 contracted the disease; in Poona, in 1897, of over 900 white soldiers so engaged, not one became infected. In the latter instance the precautions taken included merely a hearty meat meal before beginning the work of the day; the retention in camp of all cases of slight ailment or those presenting cuts or abrasions; immediate disinfection by antiseptic solutions of cuts or bruises incurred during the work, and the thorough sunning of the clothing worn, for the rest of the day, after return to camp.

Every effort should be made for the destruction of rats and mice, which are very susceptible to invasion by the pest bacillus and which obviously can escape the best sanitary cordon and neutralize the most thorough disinfection. The wholesale poisoning of these rodents is not without its dangers and, like the use of traps and ferrets, is only partially effective. Recently Danyoz has shown the possibility of destroying them in large numbers by means of bread or grain soaked in cultures of the bacillus typhi murium. Not only do the animals readily eat the infected foods, but the disease thus communicated is further propagated by the affected animal to others. The bacillus employed is pathogenic only for the rodents.

Such individuals as recover from the disease should be kept in quarantine for at least a month. Kitasato has found the bacillus of plague in the blood as long as three weeks after the beginning of convalescence.

Preventive Inoculation.—The system of preventive inoculation against plague, as devised by Haffkine, has been carried out on an extensive scale in India during the past six years. The method has been systematically tested by inoculating a certain proportion of the inhabitants of districts exposed to infection, leaving others uninoculated, and then observing the proportion of cases of the disease, and of fatal cases, among the

two classes. The results have been distinctly favorable to the use of the preventive fluid.

At Poona, inoculation was practised with anti-plague serum on the native followers of the artillery troops stationed at that point. While everything was done outside of inoculation to prevent the spread of the disease, in 859 uninoculated there were 143 cases with 98 deaths, and in 671 inoculated there were 32 cases with 17 deaths. Had the inoculated, living under the same roof, belonging to the same families and sharing the same food and drink, been equally affected, the proportionate number of deaths among them would have been 77. The inoculation therefore reduced the death rate 77.9 per cent. In 1898, at Hubli, 3,815 persons not inoculated with anti-plague serum had 446 attacks, while 26,428 persons twice inoculated had only 31 attacks. If the latter had suffered proportionally as much as the non-inoculated they should have had 3,089 attacks—and such examples might be largely multiplied. In a statement published in June, 1899, Haffkine states that in the large number of inoculations made with anti-plague serum, the difference in number of attacks occurring in inoculated and uninoculated was over 80 per cent., often approaching 90 per cent. The lowest in his experience was 77.9. The case mortality also was only half as great as among the uninoculated.

To make the prophylactic material, Haffkine cultivates in bouillon luxuriant growths of plague bacilli, usually obtained from the livers of plague patients, by adding to the nutrient medium an abundance of fat exposed to free aëration. For this purpose he employs the clarified butter, or "ghee," commonly used in India. This floats on the surface of the bouillon, and after inoculation of the latter the growths extend downward in a stalactite formation, leaving the liquid limpid. When the fluid is filled with an abundant growth, the flask is shaken and the stalactites are broken and fall to the bottom; fresh growth then occurring from above downward. In this manner, half a dozen crops are obtained in the course of a month, filling the flask, when shaken, with an opaque milky emulsion. The micro-organisms are then destroyed by a temperature of 70° C., maintained for one hour, and the final result is an abundant deposit with a clear supernatant fluid. Injected subcutaneously into animals, the sediment produces a local inflammation and a nodule at the seat of inoculation, but is accompanied with little fever or general disturbance. The injection of the fluid, on the contrary, causes a considerable rise of temperature with malaise, but no local effects. A mixture of the clear fluid and deposit is used in inoculation against plague, about 5 c.c., usually divided into three doses which are administered about ten days apart, being the amount employed for adult males. The injection is followed by an unpleasant reaction with pyrexia, 101° to 103° F., and general symptoms resembling a mild attack of plague; in some cases even producing enlargement of the glands and lasting several days. The prophylactic serum begins to act in twelve to fourteen hours, thus arresting or mitigating the disease in individuals infected several days before. The effect of an inoculation of plague serum appears to be of protective value over a single epidemic, but experience has not as yet shown how long the immunity persists.

Yersin, Calmette and Borrel succeeded in producing a certain amount of immunity against plague, in rabbits, by injection of cultures of this

bacillus killed by heat at 58° C. They further found that the serum of such animals had certain protective powers when tested on mice. Later, Yersin and Symmers endeavored to produce a prophylactic serum from horses, by the injection of dead and living cultures of the bacillus of plague into these animals. Yersin's serum promised fairly well at the outset; but Symmers, working along the same lines, concludes that "the strength of the sera secured is not sufficiently great to warrant any hope of their being of therapeutic use in an actual epidemic of plague."

Pneumonia.

Occurrence.—Acute croupous pneumonia is a disease which, as might be expected, considering the conditions of military life, though not one of the most common to which the soldier is exposed on service, is yet not of infrequent occurrence nor unproductive of considerable mortality. Though ordinarily the disease occurs only sporadically, yet at times it appears to take on a distinctly contagious character, and well-defined epidemics of pneumonia among soldiers, either in garrison or in the field, are by no means infrequent. Under such conditions, it is reasonable to assume the existence of some common depressing influence, by which a number of individuals are predisposed to an infection to which, under ordinary circumstances, they would be largely insusceptible. In considering the occurrence of this disease in the military service, it should not be forgotten that pneumonia may either occur primarily or be consequent to some other disease, especially influenza and measles; and it is particularly during epidemics of the latter affections that the rates for pneumonia attain their maximum. While the disease not infrequently occurs among troops in garrison, it is considerably favored by the exposure incident to field service.

The rates in our army for pneumonia, since the Civil War, have steadily decreased as a result of the greater care given to the comfort and welfare of the soldier, as shown by the following figures:

Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1861–1866 (Civil War)	32.45	7.79
1868–84	6.55	1.01
1885–94	4.28	.76
1895-98	3.66	.51
Year 1898 (War with Spain)	4.84	.83
Year 1897	2.96	.21

The case mortality of the disease has also greatly diminished, but this is probably due to a more rational line of treatment than to any decrease in the virulence of the infection. As compared with the rates for foreign services, those for our army are extremely low—thus in the German army the admissions and deaths from pneumonia have been as follows:

Period.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1881–82 to 1885–86	11.0	0.19
1886–87 to 1890–91	10.5	.43
1891–92 to 1895–96	9.3	.36
Year 1896–97	6.7	.25

It is seen that in the German army the death rate has increased while the proportion of cases has diminished, a fact which can be explained only on the supposition of an increase in the gravity of the affection. In the Russian army the following are the more recent rates:

Year.	Admissions per 1,000 strength.	Deaths per 1,000 strength.
1890	10.4	0.99
1891	10.2	.90
1892	8.7	.81
1893	10.7	.87
1894	7.7	.62
1895	8.3	.66
1896	7.7	.62
1897	6.4	.49

In the Austrian army, for the year 1897, the admissions for pneumonia, per thousand strength, amounted to 5.1, while the death rate was .49.

Cause.—The cause of pneumonia is the specific micrococcus discovered by Sternberg, of the United States army. It usually occurs in pairs of rather small oval, conical or lancet-shaped organisms, the broader ends being in apposition. The organism varies somewhat in size. In some cases atypical or involution forms are seen, especially if the culture be more than twenty-four hours old. No capsules are usually observed in cultures, with ordinary methods of staining. It is not motile, has low powers of resistance and is readily destroyed by either thermal or chemical methods of disinfection. The micro-organism is cultivated with difficulty, and at times dies out after several generations. On blood-serum it occurs as minute, colorless, transparent colonies, resembling very small drops of dew. On glycerin-agar there is a feeble growth of minute grayish colonies. The most favorable temperature for its development is about 37° C. It does not grow at temperatures below 25° C. nor above 42° C. When injected into certain animals, especially mice and rabbits, the latter die rapidly from septicæmic infection. Great variation in the virulence of the organism is observed.

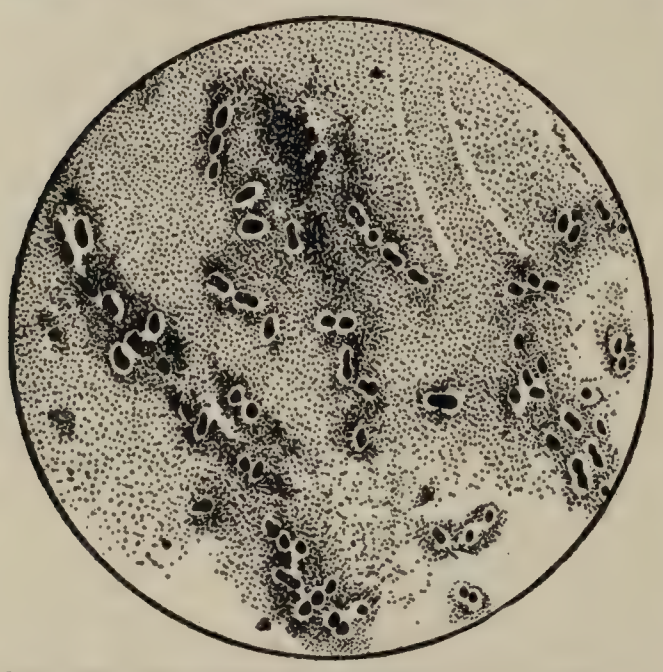


FIG. 350.—Micrococci of Pneumonia in Sputum. (After Abbott.)

Dissemination and Infection.—The specific micrococcus of pneumonia is found in the sputum of practically all persons suffering from this disease. It has also been found in acute peri- and endocarditis, acute pleuritis and empyema, acute meningitis and otitis media. After death it may be found, in varying numbers, scattered throughout the body. It has been found to be usually present in the mouth cavities of healthy individuals, and by some has been thought to be present in the mouth of every one at some time or other. While the micro-organism usually loses much or all of its virulence by artificial cultivation, its original qualities are re-

tained in sputum, blood and other pathological exudates for considerable periods, according to Abbott for as long as fifty-five days, even in the dried condition. It is not unlikely, therefore, that dried pneumonic sputum, when ground into dust and inhaled, may induce the occurrence of the disease in susceptible individuals. This condition of susceptibility is, however, essential. "There must be some predisposing cause, for the micrococcus is widely disseminated and is often present in the mouths of healthy persons without producing any ill effect. Under ordinary circumstances the protective mechanism of the body prevents invasion." Since the micro-organism

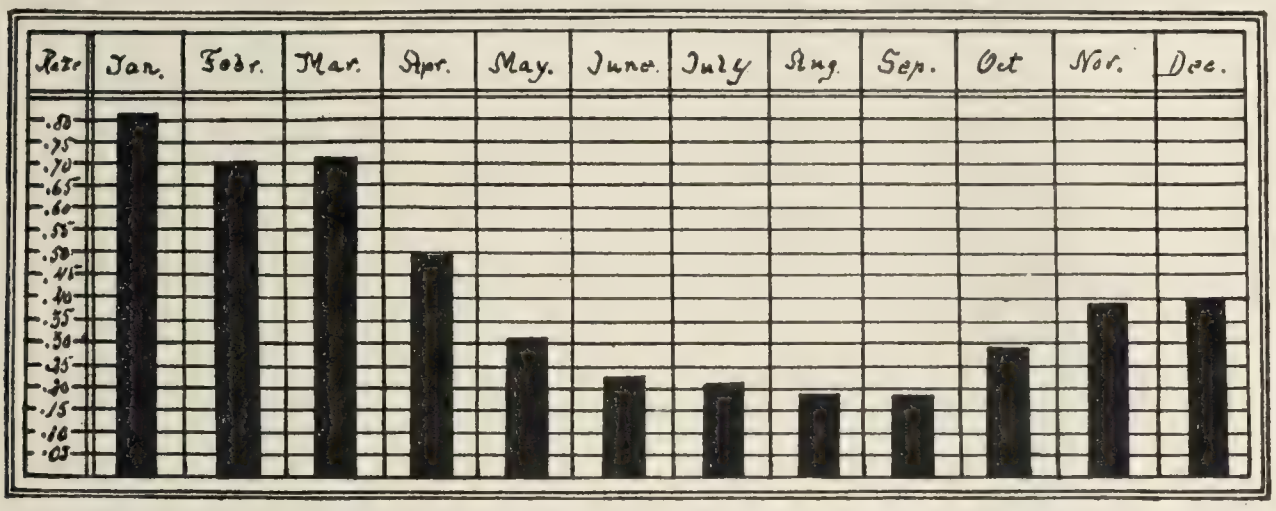


FIG. 351.—Distribution of Cases of Pneumonia in the United States Army, per Thousand Strength, Occurring Monthly during the Decade 1875–84.

of pneumonia is so frequently present in the mouth, it is probable that the sporadic cases of the primitive disease so commonly seen are the result of auto-infection depending upon a lowered vital resistance. As the lungs are the seat of attack, it would appear that the infective organism gains entrance by the air passages; though there is some evidence that it may be brought to the lungs from distant parts by the vascular or lymphatic circulation.

Predisposing Causes.—Among the predisposing causes of pneumonia those of latitude and season are of much importance, the disease being most common in cold climates and during late winter and early spring.

The distribution of the disease by months is shown in the above diagram; while the influence of climate upon its occurrence is apparent in the fact that the admission rate per thousand strength, for the year 1899, was 9.50 for troops stationed in the United States and 3.58 for those serving in the tropical islands. The disease, once contracted in the tropics, appears to be relatively more fatal than in the temperate zone; the death rates for the same year being .63 per thousand for the tropical islands and 1.40 for troops at home stations.

The negro race appears to be especially susceptible to pneumonia; the rates per thousand for our own service, for the decade 1879–88, being 7.52 for admissions and 1.79 for deaths among the colored troops, and but 4.46 and .76 respectively for the white troops. Among the whites, figures for the seven years 1890–96 showed the American-born to be about twenty per cent. more liable to contract the disease than soldiers born in Ireland, Germany or England. Age appears to be a factor of no small importance—soldiers under 25 years of age and over 50 years being more than twice as liable to contract the disease as those between 25 and 35 years of age. Among the several arms of the service, the admission rates per thousand

strength, for the period 1890–96, were 4.12 for cavalry, 3.46 for infantry and 2.95 for artillery.

Pneumonia is especially apt to develop after exposure to sudden and extreme variations in temperature. Troops returning from service in the tropics, and especially such as are insufficiently clothed for the colder climate, are particularly liable to this disease. Wetting appears not infrequently to precipitate an attack, as do exhaustion and alcoholism. The disease often occurs in soldiers who, after having been exhausted by fatiguing exercise, expose themselves while sweaty to chilling drafts. Insufficient heating of barracks has been thought, with some reason, to favor pneumonia. Repeated outbreaks sometimes occur in the same buildings, especially casemates and old log structures. It is a matter of common knowledge that outbreaks of this disease among soldiers often occur at the same time as epidemics of pneumonia or influenza in cavalry horses, with whom the men come in constant contact.

Prophylaxis.—From what has been said, it is evident that measures having reference to the prevention of pneumonia among troops are particularly those which look to the maintenance of a high physical tone. Good and sufficient food, suitable clothing and shelter, rational exercise in the open air, cleanliness of person and temperate habits are all important. Chilling after drills and exercise should be avoided.

When pneumonia assumes an epidemic or infectious type, the patient should be isolated. All the precautions required in the case of tuberculosis should be taken in this disease also. Attendants in charge of pneumonia cases should be well nourished, have sufficient rest and not be in too close relation with the sick; bearing in mind that by being overworked and in constant association with the patient they offer the conditions most favorable to their own infection.

Scarlet Fever.

From its comparative rarity, this affection can scarcely be regarded for our own army as a soldier's disease, but is here included since it is less uncommon in the military forces of other nations. During the period 1868–98, there were reported only 160 cases of scarlet fever in a total numerical strength for this period of 859,908 men. In these 160 cases there were altogether but 6 deaths. The disease occurs in garrison rather than in camp, there being but 12 cases during the year of war with Spain. Of these 12 cases, however, 3 died, while of 148 cases occurring during the previous thirty years of peace but 3 succumbed—thus showing the unfavorable influence of the exposure unavoidably incident to treatment in field hospitals. The admission rate, per thousand strength, was .19 for the period 1868–84; .18 for the period 1885–94 and .21 for the period 1895–98. In the Austrian army, for 1897, the admission rate is given as .30 per thousand strength, and the death rate as .01. In the German army, scarlet fever has occurred as follows:

Period.	Admissions per 1,000 strength.
1881–82 to 1885–86	1.2
1886–87 to 1890–91	.95
1891–92 to 1895–96	.92
Year 1896–97	.66

Epidemics of scarlet fever have frequently prevailed among children living at our army posts, without the troops being affected. The disease usually occurs in late winter or early spring. Its etiological factor is unknown, though Klein has isolated a streptococcus from cases of this affection which he regards as the causative agent. The contagion of scarlet fever is probably not developed until the eruption appears, and is especially to be dreaded during desquamation; when the poison is spread by the fine particles of epidermis which are disseminated from the person. The morbific agent is very tenacious of life, and may cling to rooms, clothing and other articles for long periods, retaining its power to reproduce the disease under favorable conditions. The infection also appears to be given off by the breath and in the secretions from the nose, mouth, ears and kidneys. The disease does not seem to be spread by water, although infected milk appears to have caused outbreaks. Infection is almost always contracted by inhalation. The incubation period is one to six days; the quarantine required is usually from seven to nine weeks, or until desquamation is perfected. Preventive measures include isolation of the sick as a matter of the first importance. The apparel, equipments and former surroundings of the patient should be carefully disinfected. All discharges should be disinfected before removal from the room, and the arrest of contagious material from the skin secured by the application of some antiseptic ointment. The convalescent should not associate with others until all desquamation has ceased, the process being aided by repeated bathing in warm soapsuds. Careful shampooing of the head is essential in securing final disinfection of the person.

Smallpox.

Occurrence.—Until well within the past fifty years, this disease has prevailed generally among armies; being regarded as one of the most frequent and at the same time most fatal affections to which troops were commonly exposed. Its prevention among soldiers by means of vaccination was not attempted until 1831, when this operation was introduced in the army of Würtemberg. Some years later, it was taken up in other armies and practised with more or less thoroughness.

During the Revolutionary War, the failure of our invading expedition to Canada was largely due to a scourge of smallpox among the Continental forces. It was present among our troops during the war with Mexico; and during the Civil War there were 18,962 cases with 7,058 deaths from this cause. In the Confederate army of northern Virginia, from October, 1862, to January, 1864, there were 2,513 cases and 1,020 deaths. During the Franco-Prussian War the German troops, who had been carefully vaccinated, had only 278 fatal cases of smallpox in a total strength of 913,967 men; while among the poorly protected French troops, the deaths from this cause were said to have amounted to 23,400—and Coustan states that during the siege of Paris the mortality from smallpox among the besieged forces was no less than 6.76 per cent. In the military hospitals, during that war, the German wounded escaped variola where the French wounded prisoners were generally attacked. The lesson was not lost on the French authorities, and a vigorous system of vaccination was

later instituted—so that 92 deaths from smallpox in 1877 were progressively reduced to 4 in 1890 and 3 in 1892. In the German army, excluding the Saxons and Bavarians, for the years 1873–74 to 1896–97, inclusive, there were but 17 cases of variola in a constant strength of over half a million men, and of these 17 cases but 2 died. In the Italian army of 204,312 men, for the year 1897, there were but 2 cases of variola; in the Russian army, for the same year, the admission rate per thousand amounted to .4 for this disease. In the British army, for the years 1888–98 inclusive, there were no cases of smallpox among such troops as were stationed in the temperate zone. In the tropics, however, the disease prevailed to no small extent; the admissions, per thousand strength, being 1.1 for China, .8 for India and 1.7 for Egypt and Cyprus. This difference was undoubtedly due to the general dissemination of the disease among an unprotected native population. In our own army, for the thirteen years 1885–97, there occurred but six cases of smallpox, and in these instances the fact of previous vaccination could not be determined. In the year 1898, however, our troops on foreign service were brought in contact with an unvaccinated native class, and furthermore consisted largely of recruits hastily enrolled in an expanded and provisional army during the war with Spain. These men, examined for enlistment largely by civilian physicians, were undoubtedly less thoroughly vaccinated and protected against the disease. That this, indeed, was actually the case, is shown by the fact that of the regulars and volunteers serving in the Philippines during 1899, the admission rate for smallpox was 4.80 per thousand strength among the former, and 9.60 among the latter troops. The relative death rates from this disease showed an even greater difference than the admissions; the regulars having a death rate of 1 per thousand strength, while among the volunteers this rate was 3.36 per thousand. For the calendar year 1898, the admission rate, for the entire army, was .40 per thousand; from the troops in Porto Rico the admissions were 1.04 and the deaths .52 per thousand, while in the Pacific islands the admissions were 5.51 and the deaths 2.07. For the entire military force, regulars and volunteers, May, 1898, to June, 1899, inclusive, the death rate from smallpox was .57 per thousand.

Infection and Dissemination.—The cause of smallpox is as yet undiscovered. In the great majority of cases the disease appears to be directly transmitted from the sick to the well through the medium of the atmosphere, and this power of aërial convection is one of the most striking characteristics of smallpox. Persons unprotected by vaccination apparently contract the disease by simply breathing the air of the space in which a smallpox patient is confined. There is no evidence for its transmission by food or drink; but persons or things which may have been in contact with the patient are capable of conveying the infection. Power states that the infectious agent may be carried by the air, particularly when a large number of smallpox cases were aggregated and the atmosphere was moist, for as much as a mile—and this is a matter for consideration in the establishment of isolation hospitals. The incubation period of the disease is about twelve days, and its period of infectiveness is at least six weeks in severe cases. The period of highest infectivity is believed to be during the stage of desquamation, when the morbific agent, whatever

be its nature, is dispersed with the fine particles of scab and epidermis shed by the patient. The disease appears to be contagious at an early stage; after exposure to an infection the susceptible individual should be quarantined for a fortnight. A certain proportion of individuals, according to Notter and Firth about five per cent., appear to be naturally immune to the disease.

Soil and climate appear to have no influence on the occurrence of smallpox. Season appears to affect its prevalence to some extent, and in temperate climates the mortality curve is above the mean in the late winter and early spring. In the tropics, the disease is said to prevail chiefly during the hot season, the rains checking it to a great extent. The negro and colored races are especially susceptible to the smallpox and also suffer a heavy case mortality where vaccination has been imperfectly performed. During the Civil War, the admissions among the white troops for variola and varioloid amounted to 5.5 per thousand strength, while the admissions from colored troops for the same cause amounted to 36.6 and the deaths to 12.2.

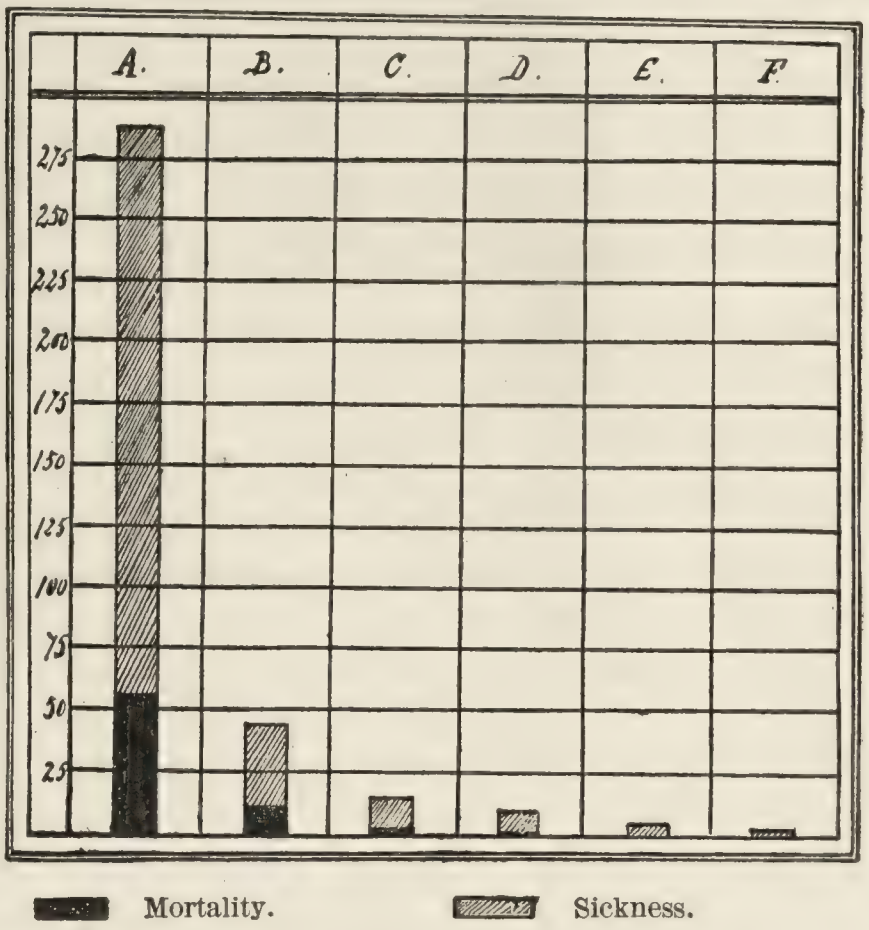


FIG. 352.—Vaccination and Smallpox in the Italian Army. *A*, Never had variola or been vaccinated in childhood, and not yet vaccinated in the army; *B*, either had variola or been vaccinated in childhood, and not yet vaccinated in the army; *C*, never had variola nor vaccinated in childhood, and vaccinated in the army without success; *D*, never had variola nor vaccinated in childhood, and vaccinated in the army successfully; *E*, had variola or was vaccinated in childhood, and vaccinated in the army without success; *F*, had variola or was vaccinated in childhood, and vaccinated in the army successfully. (After Livi.)

Prophylaxis.—There is no evidence that the smallpox poison multiplies outside the human body; hence for the prevention and eradication of this disease, systematic vaccination is the measure of by far the greatest importance. When arm-to-arm vaccination was practised in armies, great difficulty was found in obtaining the necessary amount of virus, and it was also impossible to eliminate entirely the danger of transmitting certain constitutional diseases. Animal vaccine disposes of this danger, and places at the disposal of the military sanitarian as large quantities of prophylactic material as may be desired. With improved virus and better technical methods of inoculation, the proportion of successful vaccinations has steadily increased. In the Italian army, of 3,095,571 vaccinations and re-vaccinations made during the period 1867 to 1897 inclusive, Livi states that the rate of success increased from 260 per thousand in 1867 to 698 per thousand in 1897. In the last named year, in the Belgian army, the number of successful primary vaccinations was 69.91 per cent.; of those previously vaccinated, 43.21 per cent.; of those said to have had smallpox, 20.50 per cent. In our own service,

army regulations require that as soon as a recruit joins any rendezvous, regiment or post, he shall be examined by a medical officer to ascertain whether vaccination is required. In such cases as present no evidence of successful vaccination within a reasonable period, the operation is to be performed immediately. The date and result of last vaccination are to be noted in the company descriptive and deposit book, and also on the descriptive list of the man in case of transfer. This system is not sufficiently comprehensive and leaves too much to the discretion of the medical officer. It should be required that all young recruits be vaccinated immediately on enlistment, and that they be examined after ten days and re-vaccinated if the first operation has not been successful. In such as still prove refractory the operation should be repeated at the end of three months. In time of epidemic, the thorough vaccination of the whole command should be practiced. For old soldiers, after being vaccinated on re-enlistment, no repetition of the vaccination, if unsuccessful, will ordinarily be necessary. The practice of simultaneously making several points of inoculation, as is done in European armies, has much to commend it as reducing liability to failure; and, in general, the total area of the cicatrices should not be less than half a square inch. The incubation period of vaccinia being shorter than that of smallpox, it is possible to modify or even entirely prevent an attack of the latter by vaccination performed some days after infection. This is especially the case with re-vaccination, the incubation period of which is often shorter than primary vaccination. The operation, if successfully performed within three days after exposure to smallpox, will prevent the appearance of the symptoms, and in all likelihood the attack will be arrested or modified if vaccination be performed as late as the fifth day. The few attacks that occur between six and nine days after successful vaccination are mild, and practically none commence later. With regard to what may be accomplished in controlling epidemics of smallpox, the recent work of army medical officers in Cuba and Porto Rico is a conspicuous example; in the latter island nearly a million people being vaccinated and the disease practically eradicated in less than three months. In the Cuban epidemic at Holguin, where about 12,000 cases of the disease were treated, not a single soldier of the well-vaccinated command contracted smallpox, though the men were constantly engaged in sanitary police and in performing guard duty at the lazarettos and infected points.

In addition to the prompt searching out, vaccination and isolation of all persons who may have come in contact with a smallpox case, the patient should be carefully isolated. All clothing and other articles exposed to contagion, which cannot be readily disinfected, should be burned. During the stage of desquamation, fixation of the contagious matter should be accomplished by smearing the skin with olive oil, vaselin or carbolized glycerin. All discharges from the nose, mouth and elsewhere should be received into vessels containing a disinfectant solution. The scabs which have fallen off should, as far as possible, be collected and burned. Isolation should be maintained until the last scab has disappeared. The surroundings of a case of smallpox should be carefully disinfected. No special prophylactic precautions on the part of the attendants, provided they are thoroughly protected by vaccination and are in a healthy physical condition, appear to be necessary

Vaccine Material.—If the supply of vaccine virus be inadequate, the arm-to-arm inoculation of material from vaccinia pustules, provided due care is used in the selection of the subjects, is of advantage, and, if properly carried out, may be rendered largely free from justifiable criticism. This method was employed during the Civil War. The use of bovine virus is, however, always preferable. Where crusts or charged points of this material are used, the virus is unavoidably contaminated with pyogenic bacilli, which, on inoculation, may produce mixed infections of considerable severity. It being practically impossible to produce a vaccine virus originally free from bacterial contamination, the germs unavoidably present should hence be subsequently destroyed or rendered harmless. This is readily done by the use of chemically pure glycerin; and virus stored in this substance for three or four weeks is rendered practically sterile as far as extraneous organisms are concerned. The modern method of preparing glycerinated pulp-vaccine, much to be preferred for the military service, is given by Copeman as follows:

A calf of suitable age, about three to six months old, is kept in quarantine for a week, after which, if it appears healthy and no reaction is given to tuberculin, the preparation of which has been described in a previous chapter, it may be removed to the vaccinating station. It is there placed on a tilting-table, and the lower part of the abdomen, as far forward as the umbilicus, is shaved, washed with a 2.5 per cent. solution of carbolic acid and then rinsed with sterile water and dried with soft sterilized towels. With a sterilized sharp scalpel, incisions parallel to the long axis of the body are then made on this clean-shaven area. The depth of the incisions should be such as to pass through the epidermis and open the rete Malpighii, if possible without drawing blood. As these incisions are made, glycerinated calf-lymph, which by examination is known to be free from extraneous organisms, is run into them by means of a sterilized blunt instrument, and the point of the scalpel is also from time to time dipped in the vaccine emulsions. After five days, or one hundred and twenty hours, the vaccinated surface of the calf is first thoroughly washed with warm water and soap, rubbed over it by the clean hand of the operator, and finally the whole area is cleansed with sterile water. The remaining moisture is then removed by sterilized sheets of blotting-paper. The vaccinated incisions will now appear as lines of continuous vesicles raised above the surface, each line separated from its neighbor by about one-fourth inch of clear skin. Any crusts which appear in the vesicular lines are picked off with a blunt sterilized instrument. The vesicles and their contents are then removed by means of a sterilized Volkmann's spoon and are transferred to a sterilized bottle of known weight. By going over the lines only once with the spoon, it is quite easy to remove the whole of the pulp without any admixture of blood. The abraded surface is carefully washed and may be dusted with fine oatmeal or starch and boracic powder. Subsequently the calf is transferred to the slaughter-house and the carcass is examined with respect to its healthful condition. Should this examination not be satisfactory, the vaccine-pulp from the animal is destroyed. The bottle containing the vaccine-pulp is then taken to the laboratory and the exact weight of the material ascertained. A calf vaccinated in this way will yield from 18 to 24 grams, or even more, of lymph-pulp. This

material is then thoroughly rubbed up in a sterilized mortar or in a triturating machine. When it has been brought to a fine state of division it is mixed with six times its weight of a sterilized solution of 50 per cent. chemically pure glycerin in distilled water. The resulting emulsion is then transferred to small test-tubes, which are then aseptically sealed and stored in a cool place protected from light. When required for distribution, the emulsion is drawn up into sterilized capillary tubes which are subsequently sealed in the flame of a spirit lamp. As soon as the vesicular pulp is thoroughly emulsified with the glycerin solution, agar-agar plates are inoculated from it, and after suitable incubation for seven days the colonies that have developed on the plates are counted and examined. Week by week this process is repeated, and invariably the number of colonies diminishes with the age of the emulsion; until at the end of the fourth week after the collection and glycerination of the lymph material, the agar-agar plates inoculated show no bacterial growth. The lymph is then subjected to further culture experiments, and if the freedom from extraneous organisms is positively demonstrated the emulsion is ready for distribution. The elimination of the extraneous organisms ordinarily occurs by the end of the fourth week. The only exception to this rule arises when the lymph originally contained a considerable number of spores or bacilli of the hay bacillus, or bacillus mesentericus. These organisms are very resistant to the action of glycerin; but if the precautions detailed are carried out in the treatment of the calf, they may generally be excluded. The duration of activity of glycerinated lymph in all probability varies with atmospheric conditions, with the fineness of division of the vesicle-pulp, and, above all, with the condition of the calf itself. Ordinarily, glycerinated lymph may be considered to retain its full potency for ten months and, under favorable circumstances, probably for a longer period. In military practice, however, there will rarely be a reason for keeping the lymph any such length of time, and conditions of climate and surroundings are usually such that deterioration is rapid.

In nearly all foreign armies, vaccine farms form part of the military establishment. In the French army there are five such farms, of which three are located in France and one each in Tunis and Algeria. In our own service, admirably managed vaccine stations have been established in Porto Rico and in the Philippines, since it was found to be a matter of both great difficulty and expense to secure active vaccine virus from the United States, Japan or other countries. In the stations in the Philippines, the young water-buffalo or carabao has successfully filled the place of the calf for the production of vaccine virus.

Vaccinia.—This requires brief mention, in this connection, because of the temporary disability which it often induces in newly vaccinated recruits; the rates thus produced figuring among the most frequent causes bringing about admissions to sick report. As vaccination on the arm often renders it inconvenient for recruits to drill or perform hard labor for a few days, it is customary to excuse such men as present evidence of a special inflammatory action from the performance of a part or the whole of their duties for a few days. A large proportion of such cases receive no special treatment, and are carried upon sick report as being sick in quarters.

The admissions for vaccinia during the decade 1886–95, amounted to 33.72 per thousand strength, with a constant non-efficiency from this cause of 1.06 per thousand. For the years 1896 and 1897, the rates were considerably lower than for the decade just mentioned. During the year 1898 the admission rate for this affection was increased to 46.80, while in 1899 it was still further raised to 65.33. The great elevation in the rates for these two years undoubtedly depended upon the large influx into the army of previously unprotected recruits; the re-enlistment of old soldiers, with the slight reactions following their re-vaccination, not reducing the admission rate from this cause to the same extent as when the total enlistment was smaller. This, of course, was to be expected in the expansion of the army, and is a condition which will obviously adjust itself to its former standards, under settled conditions of military strength, in the course of a few years. In 1899, a death attributable to vaccinia was reported, amounting to a rate of .01 per thousand strength. Examination of the records, however, shows that six other deaths occurred as a result of septicæmia following vaccination; a fact which emphasizes the necessity for the use of a non-contaminated vaccine virus, such as has just been described, and also the importance of observing all antiseptic precautions in the performance of vaccination. These deaths, together with the five which occurred among the volunteer forces in 1898, undoubtedly depended upon the use of a contaminated virus, such as gave rise during the Civil War, in many instances, to serious results following inoculation with matter from crusts or scabs from human sources. The untoward results just noted are no argument in favor of non-vaccination, but they speak forcibly in favor of a proper technique in carrying out the operation and the use of glycerinated and uncontaminated virus.

Tuberculosis.

Occurrence.—Tuberculosis is a disease which originates more frequently in garrison than among troops in active campaign; but, on the other hand, the arduous nature of the service required under the latter conditions is often responsible for the rapid development of a previously latent infection. The disease is fairly common among soldiers, a fact not strange when its great prevalence among the civil population is considered. It is probably true that a proportionally greater number of cases of tuberculosis occur among soldiers than develop among males of the military age in civil life, in spite of the former originally being physically sound men; but, on the other hand, the disease is of a somewhat chronic nature and not usually amenable to such treatment as can be given in the military service, and hence the discharge of well recognized cases does much to depress the rates for the military service and raise to some extent those for civil life. Military service appears afford not only to greater facilities for contracting the disease but also much more certainly to develop an existing though quiescent infection.

The mortality from tuberculosis was extremely high among troops at the beginning of the present century, but has gradually decreased down to the present time as a result of more attention to their welfare. In our own service, the admission rates for tuberculosis, during the Civil War,

amounted to 6.22 per thousand strength; the death rate to 2.53. During the second year of the war the admission rate was 9.38 and the death rate 3.05. For the period of peace 1868–84, the admissions amounted to 4.83 per thousand strength, and the deaths to 1.05. For the decade 1885–94, these rates fell to 3.39 and .59 respectively; and for the period 1895–98 they were still further reduced to 2.83 and .42. As compared with those given for other armies, these rates are low and reflect much credit upon the care given to our troops; but their existence, even at present figures, implies a certain laxity of sanitary administration. The death rate from this disease should be made to approximate zero through a more prompt and thorough elimination of those affected with it, while a higher physical standard in respect to recruits would do much to reduce the subsequent admissions to sick report from this affection. In foreign armies, figures with respect to the occurrence of tuberculosis, as given by Marvaud and contained in recent official reports, are as follows:

Nation.	Period.	Admissions per 1,000 strength.
Germany	1873–1879	4.3
	1881–1891	5.7
	1891–1897	2.57
Austria	1878–1881	4.2
	1889–1891	4.7
	1893–1897	1.76
England	1870–1883	6.1
	1885–1890	3.5
	1888–1897	3.7
Russia	1890–1897	4.2
Italy	1875–1881	3.16
	1882–1891	3.82
Spain	1886–1891	7.75

The death rates from this disease in the Russian and French armies are particularly high, being 1.6 and 1.10 respectively. The lowest death rate is given by the Belgian army, in which, as a result of careful elimination of the tuberculous, the rate was but .35 per thousand strength in 1898. For the year 1897, the death rate was .45 in the German army. Among the British troops on colonial service, during the decade 1888–97, the lowest rates of admission were given by Gibraltar, 1.9, and Bermuda, 2.4. The highest rates were given by the troops in India, 4.2, and in Ceylon, 4.1. For the Spanish army in Cuba, in 1897, the admission rates for tuberculosis were stated to have been in excess of those for yellow fever, dysentery or typhoid fever.

Cause.—Tuberculosis results from invasion of the system and later development of the bacillus tuberculosis. This bacillus is a slender, rod-shaped organism; staining homogeneously in fresh cultures but presenting a beaded appearance in old cultures or in sputum. The bacillus is non-motile and has not been shown to form spores. It possesses the property of retaining certain stains, even when subjected to the action of comparatively strong decolorizing reagents. It is stained by Gram's method. The bacillus cannot readily be cultivated on ordinary nutrient media, but may be grown on blood-serum, nutrient agar, and bouillon to which gelatin has been added—developing only at body temperature. It

is killed by heat at 55° C., but is not destroyed by ordinary drying or by freezing. In the dry state it is much more resistant to heat than when moist. It does not multiply outside the body except in artificial cultures. When grown on blood-serum, the colonies appear, after three or four weeks, as dry, granular, cream-colored, slightly elevated patches with irregular margins. Sometimes these patches become confluent, to form a dense, dry granular mass with irregular surface and of a creamy white color. The growth is very friable, but coherent. On glycerin-agar the growth is similar but not so vigorous; on glycerin-bouillon the growth occurs in the form of floating patches, or as a membrane similar in appearance to the growth on blood-serum.

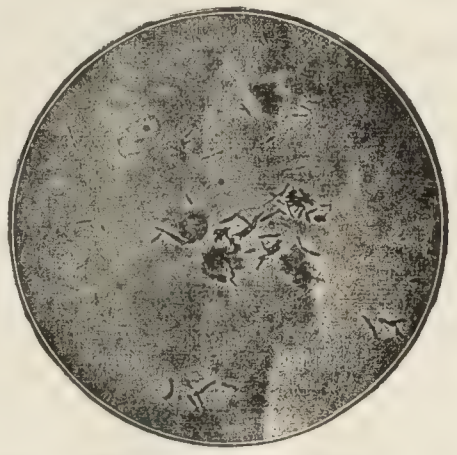


FIG. 353.—Tubercle Bacilli in Sputum.

Dissemination and Infection.—Every tuberculous soldier is a source from which the disease may be propagated to his comrades. Exactly the manner in which the infectious material is thrown off, depends upon the anatomical location of the tuberculous lesions. Undoubtedly the disease is most commonly disseminated by infected sputum, but this is merely because the specific bacilli more commonly find in the respiratory tract the conditions which are favorable to their development. It should not be overlooked that under certain conditions the urine, fæces or discharges from superficial lesions may be proportionally as infectious as the sputum.

In the sputum of those affected with pulmonary tuberculosis the specific bacilli are usually found in enormous numbers. When such infected sputum is dried, pulverized and disseminated as dust by air-currents, the infectious material may be inhaled by those within its sphere of action and may reproduce the disease in susceptible individuals. The same may also occur with respect to tuberculous urine, fæcal matter and suppurative discharges. In a comparatively dry state the vitality of the bacillus is very great, and it has been shown to retain its virulence for as long as seven to ten months. In the wet state, its virulence is retained for about six weeks; but in this condition it is comparatively harmless, though not entirely so. Cornet found that the dust in rooms occupied by consumptives contained virulent tubercle bacilli in a large proportion of cases. Such dust, disturbed from cornices or out-of-the-way places, even after several months, is often capable of producing an infection, and to its agency the appearance of many cases of obscure origin may be attributed. In a study of consumption occurring in Philadelphia, it was found that certain infected tenement houses were apparently responsible for a large proportion of cases; in some instances, every family successively occupying these houses presenting one or more cases of the disease after an occupancy of any duration. The observations have a practical application to the military service in relation to the disinfection of barracks.

While the breath in consumptives does not appear to convey the infection, fresh tuberculous material may readily be transmitted to food or drink by unwashed hands or similar agency, and give rise to the disease when taken into the alimentary tract. In ten examinations of the hands of hospital attendants in wards where consumption was being treated,

Vigoura found the tubercle bacilli present in two instances. In the same way, infected individuals who cough over food may also disseminate the affection. Flies feed greedily on tuberculous material, and their importance as carriers of the specific bacilli has only recently been appreciated. Much important evidence on this point has lately been collected. Spillman and Haushalter examined flies and fly excreta from a hospital ward and found tubercle bacilli in both. Hoffman examined the intestinal contents of flies taken from a room where a death from phthisis had recently occurred, and found the bacilli in four out of six instances, as well as in the excreta on the walls and furniture. Guinea-pigs inoculated by him with fly intestine became tuberculous. Alessi fed flies with phthisical sputum and then produced tuberculosis in rabbits inoculated with their dung. It is thus apparent that food may be readily contaminated by flies, carrying infectious material. Tuberculous meat may also be a cause of the disease; and in civil life, milk from diseased animals is not infrequently infected. Clothing or other articles, when infected, may convey the disease to those persons who handle them, and in such instances the disease not rarely appears to result from accidental infection by way of the alimentary tract. Inoculation through a breach of the skin has often occurred, but such method of infection is not common in the military service; when it does occur, the tuberculous process is usually localized at the site of infection. Direct infection from the sick is comparatively rare, but there is evidence to the effect that the disease may be transmitted from the sick to the well. In instances of this sort, however, the affected individuals have usually not been free from the possibility of infection by indirect means also.

Predisposing Causes.—Tuberculosis occurs in all countries and climates, but is especially prevalent where sudden changes of temperature and damp atmosphere favor the occurrence of bronchial irritation; the tuberculous element being thus engrafted upon a simple benign affection. A dry, equable, sunny climate does much to prevent the occurrence of this disease, and the same may be said with respect to altitude. Tropical service favors the disease; thus in 1899 the rates of admission were 4.52 for the tropical islands and 3.18 for troops in the United States, while the difference in death rates was even more marked, being .67 and .36 respectively. The immediate transfer of cases developing in the tropics, to favorable climates in this country, is imperative.

The so-called tuberculous diathesis is of the greatest importance in determining the liability to the occurrence of this disease. There seems to be no doubt that certain individuals present a hereditary susceptibility to tuberculosis, and this predisposition may generally be recognized by its well-known physical signs. Among these, chest capacity is important, and it is of interest to know that in the German army, where the chest of a soldier does not properly develop under physical training, the man is regarded as predisposed to phthisis and returned to civil life.

Race exerts a considerable influence on the occurrence of tuberculosis, though no race is exempt. The negro and Indian are especially predisposed to this disease. In 1898 and 1899, the admission rates for colored troops were 4.59 and 4.20 respectively; for white troops during the same years they were 3.65 and 3.96. Among the Apache Indian prisoners re-

moved, a few years since, from Arizona to the damp climate of Alabama, the annual death rates per thousand strength, for five years, were 55, 51, 110, 146 and 110—almost wholly from tuberculosis. For the white race, nativity seems to be not without influence in modifying susceptibility to this disease. In the United States army, for the seven years 1890–96, the admission rates for tuberculosis, per thousand strength, were 3.33 for American whites, 2.97 for soldiers born in Ireland, and but 1.49 for those of German birth. In the examination of 501,068 recruits for the Union forces during the Civil War, Baxter states that rejections for tuberculosis were more frequent in blonds than in men of dark complexion; and that the proportion of rejections for this cause increased directly with the height. Age is a factor of great importance in the occurrence of the disease. For the period 1890–96 the admissions for tuberculosis in our army, per thousand of each class, were proportioned as follows:

Period.	Admissions.	Period.	Admissions.
19 years and under	5.03	30 to 34 inclusive.....	2.69
20 to 24 inclusive.....	3.44	35 to 39 "	2.70
25 to 29 "	3.09	40 to 44 "	1.87

The rates for infantry are slightly higher than for cavalry and artillery, and nearly three times as high as those for the Medical Department; the latter showing the beneficent effect of lessened exposure and freedom from over-crowding. For the period 1890–96, the admissions were about two-thirds as frequent among officers, 1.98, as among enlisted men, 2.96.

Nothing is better established with regard to tubercle than its relation to over-crowding and bad ventilation. As long ago as 1858, it was shown in the British army that the troops which suffered the most from over-crowding presented the greatest amount of tuberculosis. The custom of living in common, as in barracks, greatly favors the occurrence of tuberculosis; since where infection of a squad-room has occurred, all the occupants are equally exposed to the danger of contracting the disease. Casemates, from their dampness, defective ventilation and want of sunshine, particularly favor tuberculous infections among troops quartered in them. No more striking example of the influence of such habitations on the frequency of tuberculosis has been given than that reported by Davy in 1862, as witnessed by him at Fort Clarence, in England. At this post, converted into a lunatic asylum, the deaths from tuberculosis among insane officers and soldiers' wives, they being lodged in ordinary houses, furnished 19 and 18 per cent. respectively of the mortality from all causes. Among the soldier lunatics, who were quartered in casemates, tuberculosis caused 39 per cent. of all deaths. Bissell has recently shown that infected clothing will long retain dangerous qualities. This observer soaked in water small pieces of cloth removed from the pocket-lining of overcoats, worn by members of the National Guard discharged for tuberculosis, and almost invariably produced this disease in guinea-pigs on injecting them with the resulting fluid. A susceptibility to tuberculosis may be developed, in individuals ordinarily resistant to the disease, through insufficient and improper food, want of exercise, poor ventilation and uncleanliness of the person and surroundings. As with other infectious diseases, any circumstance which tends to lower the powers of vital resistance favors invasion.

Prophylaxis.—In the military service, the prevention of tuberculosis

depends primarily upon the careful selection of recruits and the avoidance of enlisting such as appear to have a predisposition to this disease. If such have been enlisted, they should be discharged. All soldiers affected with the disease should be promptly eliminated from the service, as their retention is a menace to others. The cures which may be obtained at the army sanitarium at present maintained for the treatment of this disease, can scarcely be regarded as permanent with the conditions of hardship and climate under which such previously infected men, returned to duty, will probably be required to serve.

Among other measures of prevention may be mentioned the location of barracks on dry, elevated, sunny sites; the provision of sufficient cubic space, proper lighting and thorough ventilation; the avoidance of sharp corners or projecting ledges upon which dust can collect, and the rendering of floors impermeable with paraffine. Spitting on the floors and walls of buildings, aside from its being an offense against neatness and decency, should be prohibited for sanitary reasons in connection with this disease. Metallic cuspidors of a pattern readily cleansed should be provided, and should contain a small quantity of some odorless disinfectant solution so as to keep the sputum in a moist condition. These receptacles should be cleansed and scalded daily. Box cuspidors containing sawdust, as too often found in barracks, should never be employed. They are not only a danger to health but are often ignited by cigar and cigarette stubs. In the routine cleaning of barrack-rooms the use of dusters should be avoided; all dust should be removed from shelves and projecting ledges by means of damp cloths. It should not be forgotten that a squad-room which has contained a case of tuberculosis is not safe for occupancy by others until disinfected. Meat from tuberculous animals should be rejected for issue. An abundant diet containing a considerable amount of fat appears to be of value in the prevention as well as the treatment of this disease. Chilling and exposure, which favor bronchitis and pleurisy, predispose to tuberculosis and should be avoided. Systematic exercise in the open air, especially such exercise as increases the mobility and capacity of the chest, is desirable.

With reference to the measures to be applied to the affected individual, the disinfection of the sputum and other discharges from persons suffering from various manifestations of the disease is of the most importance. The patient should be impressed with the fact that he is at all times a possible source of infection, and that it is quite within his power to control the spread of the disease to others, and perhaps to avoid re-infection in his own case, by proper attention to a few simple details which in no way interfere with his comfort. Special spit-cups should always be provided for the sick; since otherwise while endeavoring to use the ordinary receptacles on the floor they will frequently cause the contamination of the latter. When the spit-cups cannot be used, clean rags or rice-paper napkins may be employed, and these subsequently destroyed by fire. Bed or body clothing, soiled with tuberculous material, should be at once removed and disinfected. The clothing or bedding of the tuberculous should never be used by the well. All blankets should be frequently sunned, and great care taken to prevent their being shaken under circumstances which would allow the dust to be inhaled or become a means of infection to others. The tuber-

culous individual should be provided with separate eating utensils, and these should be disinfected after use; the uneaten portions of food should be burned. All personal contact between the healthy and the tuberculous is to be avoided as much as possible.

Typhus Fever.

Occurrence.—An entire chapter might be devoted to the historical pathology of typhus or spotted fever. The disease is as old as the disputes of nations and has occurred in formidable epidemics among troops in the field from antiquity down nearly to the present time. During peace it has always been of comparatively subordinate importance, although its occurrence in armies has given rise, from time to time, to disastrous outbreaks in the neighboring civil population. It is known to have prevailed during the Peloponnesian war; and in 1489 it destroyed 17,000 of the troops of Ferdinand at the siege of Grenada. In 1528, at the siege of Naples, over 5,000 of the French nobility lost their lives from typhus in a period of about three weeks, and the French army of 30,000 men was almost destroyed. In 1542, in the German army at Ofen, according to Hauser, typhus claimed 30,000 victims. Before Metz, in 1552, the besieging Spanish army lost 30,000 men in less than two months, compelling the abandonment of the siege. The roads taken by the retreating army were said to have been lined with the dead and dying. In 1586, it decimated the army of Maximilian II.; in 1620, the Bavarian troops serving in Bohemia lost over 20,000 men from spotted fever. In 1628 and 1632 the disease ravaged the Swedish army. Both the Royal and Parliamentary armies in England, in 1643, suffered severely from typhus; in the wars of Louis XIV. it caused enormous losses in the French army. At the siege of Torgau in 1760, it is said that over 30,000 men, out of a total of 35,000, died of this disease in a few months. Typhus is reported as having been one of the great factors in the mortality of our troops during the Revolution; and in 1790 the losses among the Russians from this disease were so great that operations against the Turks had to be suspended. In 1799, typhus decimated Genoa and the French force besieging it. The greatest recorded ravages of this disease, however, occurred during the later wars of the first Napoleon. At Saragossa, out of 100,000 people, 54,000 are reported as having died, chiefly from epidemic typhus. At Dantzic and Wilna, and during the retreat from Moscow, vast numbers of French troops perished from typhus. In May, 1812, the Bavarian allies of the French mustered 28,000 men—in February, 1813, it is said that this disease had left of this number but 2,500 to bear arms. In August, 1813, the first Prussian army of 60,000 men had lost one-sixth of its strength from an epidemic of typhus. Murchison states that in Mayence alone, of the 60,000 French troops composing the garrison in 1813, no less than 25,000 died of typhus in six months. According to Rawlinson, of the French armies around Paris, after the retreat from Russia, 40,000 men died of typhus in six weeks—one-fifth of the remaining force being sick. This disease raged in all the contending armies during the Crimean War, particularly among the French troops. Aitken says: "In the spring of 1856 it was computed that more than 17,000 men of the French force perished in less than three months, chiefly

from typhus." Baudens declared that of the typhus cases in hospital in February, 1856, two-thirds were devoted to certain death. The deaths among the French medical officers during this outbreak amounted to 48, and there was said to have been scarcely one that escaped attack.

Typhus undoubtedly did not occur among our troops during the Civil War, although a small number of cases were diagnosed as this affection. It prevailed among the French troops in Mexico, especially on board the ships which conveyed the native forces from northern Africa. Coustan says of these troops that they "suffered a cruel loss." In 1862–63, and again in 1867, typhus attacked the French garrisons in Algeria; Marvaud stating that of one body of 3,500 troops, 1,200 died from this disease. Its existence during the Franco-German War in 1870–71 is disputed. During the Russo-Turkish War in 1878, it was said that one time the cases of typhus were so numerous in the Turkish army as to threaten its disorganization, and the conditions in the Russian army were not much better. After the capture of Plevna, according to Coustan, 50,000 men out of a total of 120,000 died during the period of inactivity, and in May and June of 1879 it is stated that half the Russian forces near Constantinople were prostrated with this disease.

Typhus fever, in the military service, is essentially a disease of camps and sieges. Of late years, the affection has lost much of its importance to the military sanitarian. Its geographical distribution is not great; and at present, in time of peace, it occurs only among troops stationed in southeastern Europe, where the disease is endemic. In the Russian army, for the period 1890–97, the rates per thousand were as follows:

Year.	Admissions.	Deaths.	Year.	Admissions.	Deaths.
1890.....	0.6	0.04	1894.....	0.7	0.05
1891.....	.9	.07	1895.....	.3	.03
1892.....	1.8	.14	1896.....	.3	.02
1893.....	....	....	1897.....	.2	.02

In the Austrian army there were 9 cases in 1897, 4 in 1896 and 8 in 1894. There has been no well-authenticated outbreak of this disease in our own army within the past half-century. A number of localized epidemics of typhus have, however, prevailed in the civil population of the country, the infective agent being in every case imported from abroad.

Direct and Predisposing Causes.—The specific exciting cause of typhus fever has not as yet been isolated; it is said that the disease has recently been experimentally produced in Russia by inoculation with the blood of typhus patients. It is universally admitted that the most important influences predisposing to its epidemic occurrence are want, misery and hardship. Typhus appears to be largely favored by over-crowding and lack of proper ventilation; cold weather, as shown in the Crimean War, probably indirectly promotes its occurrence among troops for these reasons. Viry notes that typhus was prevalent in public institutions in the city of Metz, in 1870, when it did not appear among the French troops living in shelter-tents just outside the walls. Poor food, dampness, fatigue and other conditions lowering the resistive powers—together with psychical depression—have much to do with epidemics of this disease.

Typhus fever is highly contagious, in the strict sense of the word; and there is probably no disease which has been more frequently contracted from the sick by their attendants. Thus at Plevna, nearly all the medical officers were attacked; while during the Crimean War 12.8 per cent. of the medical officers and only .4 per cent. of line officers, among the French troops, died from typhus. As with smallpox, the specific virus appears to be distinctly transmissible from the sick to the well through the surrounding atmosphere, and infection appears to take place by way of the air passages. The poison may be harbored by and carried from place to place in fomites. Jacquot, in speaking of typhus during the Crimean War, says that "wherever troops affected with typhus have camped, the dejections and excretions which have saturated the ground are fatal to troops which follow them." The morbific agent appears long to exist in infected clothing and dwellings. The activities of the specific virus are favored by unsanitary conditions; and where the disease is introduced among troops which are poorly nourished and insufficiently clothed, and living under conditions implying over-crowding, there is every likelihood of an epidemic outbreak of the fever. The incubation period is variously stated at from six to fourteen days; though there appear to be some well authenticated cases in which it was not more than two to five days. The disease is most common during the period of youth and early maturity, as found in young soldiers, but the mortality is lower than among those of greater age.

Prevention.—It is manifest that the prophylactic measures against the disease are those that aim to prevent its introduction from without, and those that are designed to eliminate all local conditions favorable to its development. Quarantine against infected points should be rigorously maintained. Where the disease appears among troops in garrison, the sick and well should promptly be placed under canvas; for the influence of fresh air upon the virulence and vitality of this disease is undoubtedly of the highest importance. The command, if large, should be broken up into smaller bodies. Especial attention should be given to the prevention of over-crowding, to ensuring an abundance and proper preparation of food, to the avoidance of fatiguing exercise and to the maintenance of strict sanitary police. Careful watch should be kept for suspicious cases and these should be at once isolated as they appear. It should not be forgotten that the aggregation of large numbers of the sick greatly increases their rate of mortality, as well as the danger to the attendants. Tent hospitals should preferably be used, the supply of fresh air being unlimited and the floor space allowed to each patient being about two hundred square feet. The tent devised by the writer presents particular advantages for the treatment of infectious cases of such character.

As the contagion is especially virulent near and about a patient, attendants should as far as possible avoid inhaling the emanations from the sick, unless protected by a previous attack. They should not stay in the immediate vicinity of typhus patients longer than necessary, and should never sleep in a ward. They should take plenty of sleep and good food, and should frequently employ disinfectant solutions on the face and hands. The attendants, like the sick, should of course be quarantined. Careful disinfection of excreta and of bed and body clothing is always called for.

The barracks or ward, as well as all articles of furniture, clothing or equipment contained in it, should be disinfected and thoroughly aired after removal of the patient.

Yellow Fever.

Occurrence.—Yellow fever is essentially a disease of tropical and subtropical countries, and within these it is ordinarily restricted to well-defined geographical limits and, to a considerable extent, to the summer or rainy season. Bodies of troops serving within these limits of infection for any length of time, during the yellow-fever season, have uniformly been more or less affected by it. In 1648, "there occurred in Havana, and in the fleet of Don Juan Pujados, a great pest of putrid fevers. A third part of the garrison and a larger part of the crews and passengers in the vessels died." The disease was extremely fatal among the British troops which captured Havana about three centuries ago; and it is interesting to note that the regiment of loyal Americans recruited for this expedition, largely from the southern part of the country, was least affected. In 1740, in the expedition against Carthagena, its effects were most disastrous. In 1780, a force of 8,000 Spanish soldiers was landed at Havana, and within two months had lost 2,000 men from this disease. In 1794, "the vomito appeared so severely that solely of the garrison (of Havana) and of the squadron more than 1,600 victims were taken. It was indispensable to resort to a general levy to replace the losses on the vessels." In Hayti, during the rebellion of the blacks, the French army of veteran soldiers was practically annihilated by yellow fever. Of this epidemic, Lemure wrote: "In 1802 an army under the orders of General Leclerc embarked for San Domingo. The effective strength, on leaving Brest, was 58,545 men. In four months 50,270 men were dead; chiefly of yellow fever, which gave 82.5 per cent. of the total mortality. Of the 8,275 men remaining, 3,000 were sick or wounded. In 1809, seven years later, this army was reduced to 300 men, who returned to France." The French also suffered from yellow fever during their occupation of Mexico. According to Coustan, there were 1,705 cases; the fever breaking out six days after the landing at Vera Cruz. During the Civil War there were, in the Union forces, 1,371 cases and 436 deaths; and in 1867 the disease attacked a number of southern posts and caused 1,520 cases with 453 deaths. For the period 1868–84 the disease recurred almost annually among such of our troops as were stationed in the south; the average for the whole army for this period, per thousand strength, giving a rate of .78 for admissions and .33 for deaths. For the period 1885–96 inclusive, there were no cases of yellow fever in our service. In 1897 there were 7 cases with 3 deaths; in 1898, at Santiago, there were 604 cases with 70 deaths. For the period 1868–98 the rate for admissions from yellow fever was 1.17 per thousand strength, and for deaths .26. The Spanish army in Cuba has always suffered severely from this disease, especially during the epidemics of 1876–77 and 1896. The British and French troops which have been stationed in the West Indies have also been repeatedly attacked.

Cause and Mode of Dissemination.—With regard to the nature of the materies morbi of yellow fever nothing is as yet known, though inves-

tigations by many medical officers of our service have been, and are now being, vigorously prosecuted.

Reed and Carroll, of the United States army, have recently shown that the mosquito is at least one of the most important agents by which the transmission of the disease is accomplished. Not every species of mosquito serves as a carrier of the infection, however, and, as with malarial disease, a special variety of suctorial insect serves as the intermediate host. This variety, for yellow fever, is the so-called Culex tiniads of Giles, but is classified by Theobolt in a new genus, Stegamina. The first-named observers showed that while yellow fever may be transmitted to the non-immune individual by means of the bite of the mosquito which had previously sucked the blood of those sick with the disease, an interval of about twelve days in warm weather and eighteen days in cool weather was apparently necessary before the infected mosquito became capable of transmitting the infection. This period doubtless represents the time required for the parasite of yellow fever to pass from the stomach of the insect to its salivary glands. The bite of the infected mosquito at an earlier period after contamination, while not provoking an attack of the disease, does not appear to confer any immunity against a subsequent attack. While yellow fever may be experimentally produced by subcutaneous injection of blood taken from the patient during the first and second days of the disease, it has been determined that an attack of yellow fever produced by the bite of an infected mosquito confers immunity against the subsequent injection of the blood of an individual suffering from the non-experimental form of the disease.

A most thorough series of experiments by these observers showed that the excreta of the yellow-fever patient were not directly infectious to susceptible individuals exposed to their influence, and hence the disinfection of articles of clothing, bedding or merchandise is not believed by them to be necessary. This view, of course, assumes that the mosquito is unable to take into its organism any infective material present in fomites, and that the infectivity of this insect depends wholly upon its withdrawal of blood from yellow-fever cases. This point remains as yet to be demonstrated. As with malarial fever, common experience would seem to show that the parasite of yellow fever must certainly be able to maintain an extra-corporeal existence independent of the mosquito and man, and not depend upon a short cycle through these two hosts alone. Many epidemic outbreaks have apparently followed the introduction of articles infected by yellow-fever patients into districts in which the disease had been unknown prior to that time; and until the dietary capabilities of the species of mosquito in question have been accurately determined, it would be the part of wisdom to destroy any possible infectious element in articles contaminated by the secretions of the sick. The food of the mosquito family is very varied and is known to include vegetable matter and fresh blood—a piece of fresh raw meat hung up where mosquitoes have access to it being greedily attacked by them. Should the discharges in yellow fever contain the specific micro-organism, as would seem to be at least probable, it may be that the mosquito, after feeding on the bloody vomit and stools, acquires infective properties as regards the transmission of the disease as readily as if the blood were sucked by the insect directly from the yellow-fever patient himself. Certainly such a hypothesis is reasonable, and would tend

to explain many of the phenomena connected with the outbreak and spread of this disease.

Within the yellow-fever belt, infected habitations have long been regarded as the chief points from which the disease is spread, and it has not been considered that the yellow-fever patient, removed to good surroundings, was as much to be feared as the place in which the sufferer contracted his infection. Experience has shown that those in attendance on the sick in hospitals are not especially liable to contract this disease; and yellow-fever patients have not rarely been treated in general wards among susceptible patients without the disease being communicated to the latter. The investigators above named believe that a house is infected with yellow fever only when there are present within its walls contaminated mosquitoes capable of conveying the parasite of this disease. From the long period through which such infectivity often persists in dwellings which have sheltered yellow-fever cases —far longer than the life of the mosquito— the specific germ of the disease would, however, appear to retain its virulent qualities even if the transmitting agent, in the form of the mosquito as an intermediate host, were absent. Without the latter to serve as the means of inoculation the disease, of course, would not occur among the inmates; but the possibility of its later transmission, as a result of the admission of mosquitoes, uninfected at the time of entrance, should not be ignored. The fact that infection by yellow fever usually occurs at night, when mosquitoes are most active, has been abundantly demonstrated. During outbreaks in some southern cities, men who were at their places of business during the day, but who went out of town to sleep, were largely exempt from the disease.

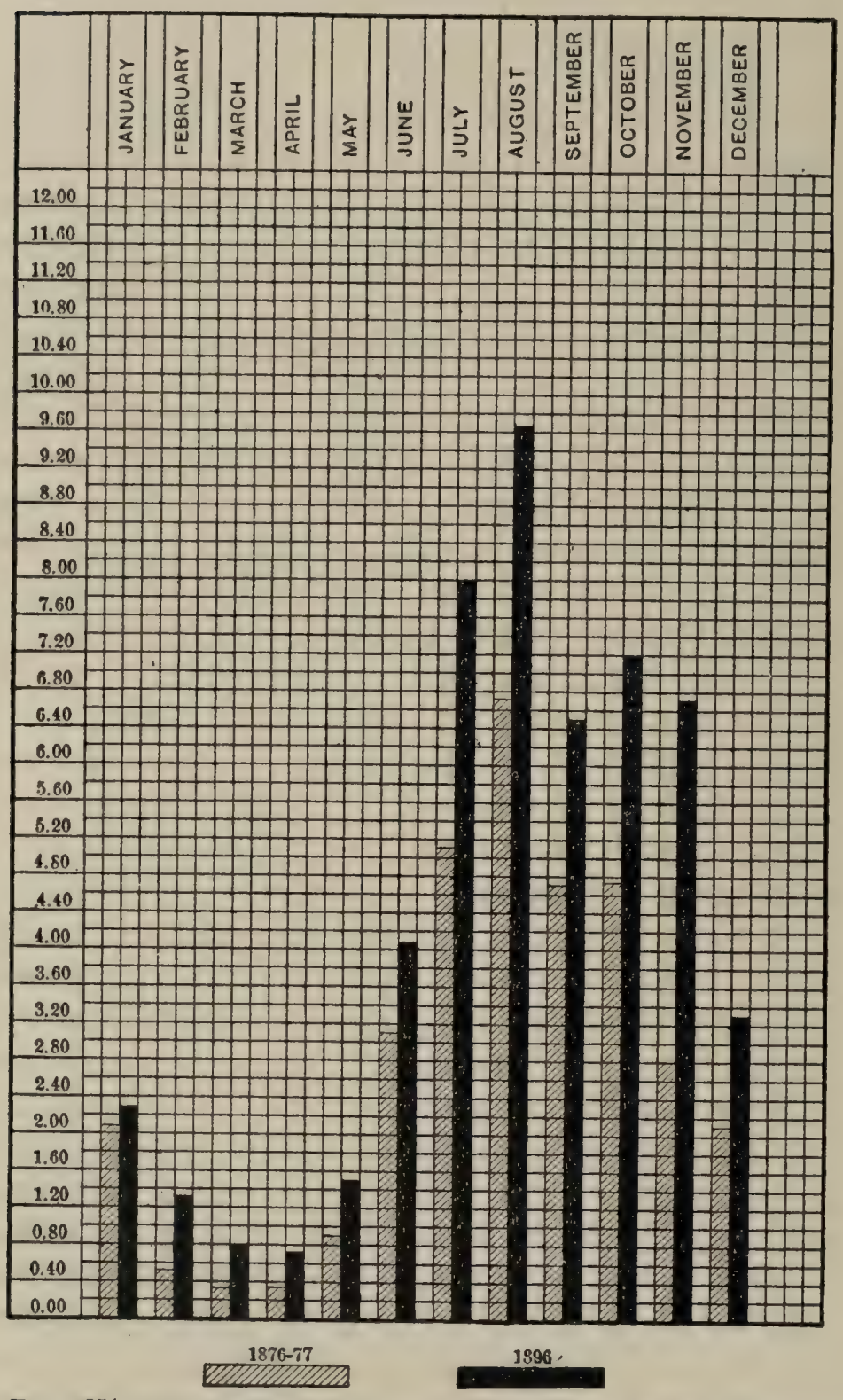


FIG. 354.—Distribution by Months of Deaths from Yellow Fever in the Spanish Army in Cuba, per Thousand Strength, during the Epidemics of 1876 and 1896.

The incubation period is short, ranging clinically from one to five days; the experimental attacks induced by Reed and Carroll had an incubation period ranging from forty-one hours to five days and seventeen hours. The accompanying diagram well shows the relative prevalence of yellow fever, distributed according to months, in an endemically infected region; it will be noticed that the disease is by far the most common during the months of greatest rainfall, when the propagation of the mosquito is favored by an abundance of water and constantly damp soil. Years in which an unusual amount of rain is noted are those in which the rates for yellow fever are above the mean. In dry years, on the contrary, the rates are low, and cold weather, with its inhibitory effect upon the activities of the mosquito, terminates the outbreaks of the disease, at least during the continuance of the former.

Absolute immunity to yellow fever is not possessed by any peoples as a racial characteristic; though, relatively speaking, those adults who are permanent residents in the endemically infected zones exhibit much less liability to contract it than do strangers newly arrived from colder latitudes. In general terms, it may be considered that among adults the susceptibility to, and mortality from, yellow fever varies directly with the distance from the equator of the place of nativity and residence of the individual. According to Barton, of each 1,000 deaths from yellow fever which occurred in New Orleans in the epidemic of 1853, the distribution of mortality was as follows:

Native Creoles	3.58
Strangers from West Indies, Mexico and South America	6.14
Strangers from Southern United States	13.22
Strangers from Spain and Italy	22.06
Strangers from Middle United States	30.69
Strangers from New York and New England	32.83
Strangers from Western United States	44.23
Strangers from France	48.13
Strangers from British America	50.24
Strangers from Great Britain	52.19
Strangers from Germany	132.01
Strangers from Scandinavia	163.26
Strangers from Austria and Switzerland	220.08
Strangers from the Netherlands	328.94

Long ago Blair wrote that among the West Indian islanders in the Seamen's Hospital at Demerara, Guiana, the percentage of deaths from yellow fever was 6.9; that of the French and Italians was 17.1; that of English, Irish and Scotch was 19.3; that of Germans and Dutch was 20; that of Swedes, Norwegians and Russians was 27.7. It has been thought that the Creole and African, irrespective of place of birth and residence, possess a racial immunity to yellow fever. This, however, does not appear to be the case. Such a relative immunity is probably only the result of an attack of the disease itself, which in early life may be so mild as scarcely to be recognized; or to a much less degree, it may be due to the transmission of a relative insusceptibility from ancestors immunized for generations through attacks of the disease. It should be noted that the immunity to this disease indoubtedly possessed by many natives of the yellow-fever belt is more or less completely lost after removal to cooler latitudes, and that such individuals on their return to the zone of endemic yellow fever often exhibit a susceptibility equal to that of total strangers to the

district. There is, therefore, no reason to believe that the negro primarily possesses any greater powers of resistance than does the white man under the same conditions, or that the negro born in cold climates is as insusceptible as the negro born and resident in the yellow-fever belt. An acquired or inherited immunity is the essential factor. It should be noted that yellow fever prevailed among the negro troops at New Orleans during the Civil War and caused considerable mortality; for the year 1898, the rates in our army for this affection, per thousand strength, were as follows:

	Admissions.	Deaths.
White troops	9.40	1.04
Colored troops	59.19	7.51

The negroes recruited for our service are rarely drawn from districts in which the disease has prevailed. The great difference in favor of white troops noted above, however, is largely to be explained by the fact that the colored troops of our army were nearly all present during the epidemic of the fever at Santiago, while a much less proportion of the total white troops was so exposed. Further, one colored regiment, on account of its supposed insusceptibility to this disease, was selected to do guard and police work at the yellow-fever hospital, thus largely increasing its opportunities for infection. A fair comparison between the susceptibility of the unacclimated white with the negro native to the yellow-fever zone may, however, be drawn from the statistics for the British troops in the West Indies. For the decade 1888–97 the rates for yellow fever, per thousand strength of these troops, was as follows:

	Admissions.	Deaths.	Constant sickness.
Europeans	3.0	1.66	0.16
Non-Europeans (negroes)	.4	.15	.02

Prophylaxis.—In preventing the occurrence of yellow fever among troops, expeditions into an endemically infected district should not be carried out in the fever season. Troops intended permanently to garrison infected points will with advantage be recruited from the native and immune population. Soldiers should be prohibited from entering infected towns, and particularly from entering houses and shops, especially at night. With this, there should be careful protection against mosquitoes, both by the use of mosquito-nets in barracks and by searching out and destroying these insects in their adult and immature stages by the methods already detailed in connection with the prophylaxis of malarial fevers. Before occupying a building in the yellow-fever zone, it should be fumigated with sulphur dioxide, both to accomplish disinfection and to destroy any insect life which may be present.

When an epidemic occurs among the surrounding population, a careful quarantine against the latter should be maintained. With the outbreak of the disease among the troops, all cases should be promptly isolated, preferably in tents. All discharges from the sick, especially the vomit and excreta, should be disinfected; if possible, by fire. The clothing and

equipments of the soldier, and those with which he may have come in contact, should be disinfected, as should the tent or barrack in which the case appeared. If possible, the troops should be moved to a locality in which the fever does not exist, or better, where it has not been known to originate; in this country, troops have habitually been transferred from southern stations to Atlanta, Ga., when an outbreak of the disease was apprehended. If such a locality is not available, the troops should be moved to high ground—preferably to an elevation of at least fifteen hundred feet. Moving camp even a mile or so may avert an epidemic, and this procedure should preferably be repeated with the appearance of every new case; for a district once infected remains so until cold weather puts an end to the outbreak. Abandonment of an infected area is essential—a fact repeatedly demonstrated in our own military service; as at Fort Brown in 1882 and at Santiago in 1899. As laid down by Sternberg: "The precautions relating to food and to personal habits do not differ materially from those with reference to cholera. The diet should be simple, and excesses in eating or drinking avoided. Nothing is more likely to favor an attack than alcoholic excesses, or to bring about a fatal result if the disease develops. Exposure to the direct rays of the sun, excessive fatigue and venereal excesses are all predisposing causes which it is within the province of individual prophylaxis to avoid. Exposure to the night air, and especially sleeping out of doors near the ground, is recognized in yellow-fever regions as an invitation to attack. Great care should be taken to avoid chilling of the body, and it is well to sleep as far above the ground as possible." Whether in camp or garrison, general prophylactic measures of importance have reference to careful sanitary police, free ventilation and avoidance of over-crowding. A predisposition to the disease appears to be caused by fatigue, especially when combined with exposure to the sun, by drinking and by insufficient or improper food. If the disease appear on board ship, the vessel should be searched for mosquitoes, and the sick should be treated on deck and landed as soon as possible. No prophylactic medication is known to be of value. Various methods of preventive inoculation have been devised, notably by Freire and Sanarelli, but experience has shown these to be without effect.

General Principles of Prophylaxis against the Infectious Diseases.

As a science, prophylaxis owes its development from the empirical to the rational to the results of modern bacteriological research. In the great majority of diseases, the etiological is no longer an unknown factor. Its importance, nature, habitat and rôle are well understood, and, with the possession of such exact knowledge, the application of measures calculated to terminate or modify its existence becomes readily feasible. Scientific prophylaxis has therefore as its cardinal principle an intimate knowledge of first causes. It undertakes to obtain an accurate knowledge of both the predisposing and exciting factors in disease, and, through logical methods, to remove or destroy them. It aims at an avoidance of contact with infectious matter, endeavors to prevent a condition of susceptibility to disease on the part of the individual and at the same time attempts to destroy or

modify such conditions of environment as favor the existence and perpetuation of pathogenic micro-organisms. Its first object is attained through early recognition of the nature of infectious disease, the isolation of the sick, the maintenance of quarantine and by the avoidance or abandonment of infected places; its second purpose being accomplished by the observation of all such measures as tend to stimulate and strengthen the powers of vital resistance. For its third object, in preventing the existence and propagation of infectious germs outside the body, prophylaxis manifests itself in all that is implied in the term disinfection. At the risk of slight repetition, the chief means of preventing or controlling infectious disease among troops, outside of the processes of disinfection, will be given a general consideration in this connection.

Early Diagnosis.—In preventing the spread of infectious disease among large bodies of men, an early and accurate diagnosis of each case is of the first importance; since it is evident that the institution of special measures of prophylaxis necessarily depends upon a recognition of the existence of an affection of a character rendering such action advisable. Sanitary officers should be prompt to realize that the early cases of an infectious nature, in the absence of proper precautions, are very possible forerunners of a serious epidemic, and as such demand far more serious consideration than the slight morbidity from such a cause would at first sight appear to warrant. The simultaneous introduction and wide dissemination of a large number of pathogenic germs is by no means essential to the origination of an epidemic, however much it may favor its occurrence. The history of infectious disease is full of instances of epidemics which have developed from a single and long unrecognized focus of infection; and in this connection, the rapid multiplication of bacterial life under favorable conditions should not be overlooked. An affection, the nature of which is for some time undetermined, may from this reason gain such a foothold among troops as to render its subsequent control a task of vast proportions, if not, indeed, almost impossible. Hence the importance of arriving at a prompt diagnosis in all cases of a possibly suspicious character, in order to justify the carrying out of well-known and demonstratedly efficient measures of prevention, which are so ready and easy of application in the individual instance.

Isolation.—As a measure of general prophylaxis, the soldier affected with a transmissible disease of grave character is to be removed at once from the camp or common habitation, and should hold communication with only those persons to whose care he may have been entrusted. Under such circumstances, every precaution should be taken to render the isolation complete, since even the slightest laxity in its maintenance may wholly defeat the purpose for which the action was taken. His various articles of personal property should also be carefully collected, removed in a manner calculated to prevent possible dissemination of the infectious agent through handling, and at once rendered innocuous through approved methods.

What applies to the individual is also applicable to the larger number. In campaign, all cases of contagious or infectious disease should promptly be removed from the army as a whole and properly segregated; while organizations in which disease has become epidemic should be de-

tached *en masse* from the command, isolated and the sick removed from time to time as their cases subsequently develop. Such infected organizations should never be augmented by recruits—who are particularly susceptible to diseases of an infectious character—nor should they hold any communication with such organizations as are yet untainted.

Troops should not be stationed where infectious disease has existed, unless proper measures have previously been employed for the destruction of the infectious agent. If an error of this kind has unfortunately been committed, the command which has been exposed should be at once isolated and held under careful observation for a time covering the incubation period of the affection, dating from the time of last exposure. This precaution, under similar conditions, should be applied also to the individual.

In time of epidemic, suspects, like the sick, are always to be eliminated from the main body; to meet their needs, special camps or stations for their detention and observation should be provided. Such camps need usually be located at no very great distance from the main body of troops, provided the regulations as to isolation are rigorously carried out; since unconfined air will rarely be a vehicle for morbific agents and mediate or direct contact with the sick is alone to be guarded against.

Soldiers who are convalescents from transmissible disease must not be relieved from restriction or returned to their camp or quarters until it is positive that they are no longer able to communicate their affections to others. With a wider understanding of the exciting causes of disease, a more exact definition of the period during which the sick may transmit their affections has become possible. As a result of this knowledge, the tendency is strongly toward the lengthening of the period of isolation; since the convalescent may long continue to be the host of the pathogenic organism by which he has undergone invasion. It is the duty of the sanitary officer to determine this period for each convalescent, according to the nature of his illness. The establishment of detention camps, for the temporary reception of convalescents and the relief of congested hospitals, will often be found advisable. Unfortunately the necessity for such segregation, learned in the military service by hard experience, is not appreciated by the general public. The retention under military control of convalescents from infectious disease is often sorely against the wishes of friends and of the patients themselves, who demand permission to complete their cure at home. Where this has been granted, as during the war with Spain, relapses are often frequent, and perhaps also a communication of the disease to new circles in the civil population.

With respect to the individual, isolation means more than simple confinement to a separate room, building or locality. It comprises, in addition to this, the employment of a specially assigned attendant who comes in contact only with those under his care; the disinfection of all infective material or discharges as soon as they are passed by the patient and before they can leave the sick-room; the disinfection of all bed and body linen as soon as they are removed from the patient and before they leave his apartment; the provision of separate eating utensils, handkerchiefs, towels and instrumental accessories; the frequent cleansing with disinfectant solutions of the surroundings of the sick; the frequent bathing of the attendant, and especially the careful disinfection of the hands after each

manipulation of the patient. The special methods of disinfection are treated of in detail in the following chapter.

Quarantine.—The term quarantine, formerly held to apply to a period of time, is now employed to designate a method by which disease of transmissible nature is absolutely debarred entrance into a territory, and among individuals, as yet uninfected. There is obviously no fixed period of quarantine for all cases, but the length of this period varies according to the duration of incubation of the particular disease against the introduction of which the precaution has been taken.

Pathogenic bacteria, even if of microscopical proportions, are nevertheless living entities, and as such are capable of being transported and of reproducing, under favorable conditions, after their own kind. Since human beings and articles designed for human use or consumption must be regarded as in most instances the vehicles of infection, the efforts of the quarantine system are chiefly directed toward the prophylaxis of disease through their exclusion whenever they appear to be probable carriers of infectious material. Quarantine, to be of value, must be absolute; in its results an inefficient quarantine is practically the same as none at all. Whenever the system is instituted, its details should receive the constant supervision of superior authority, for human nature is weak and disease is insidious. From the nature of things, a quarantine on land, on a large scale, is extremely difficult of accomplishment—but less so in the military establishment than in civil life.

All cases of epidemic disease, as smallpox, which occur within or in the vicinity of the camp or post, should be promptly known to the military authorities and strict measures taken to prevent contact by the troops; by instructions, orders and, if necessary, the establishment of a sanitary cordon around the infected point. Not only should the actual cases of the disease be quarantined against, but also all persons and things which may have been exposed to the infection. These should be traced out with the greatest diligence by the sanitary inspector; the inanimate objects should be disinfected, while the individuals who have been exposed should be segregated and kept under observation until the period of incubation of the disease concerned has passed.

In this connection it is well to remember that places of public amusement, refreshment and recreation, especially such as are in the vicinity of the camp or garrison, are always to be looked upon as possible foci of infection. As such, their patronage by troops should be discouraged, and, in time of epidemic, if necessary prevented by the use of military force.

Avoidance.—Communicable disease is transmitted by contact—if not directly with the sick, at least with their secretions, excretions or epithelial detritus—and the avoidance of such contact lies at the foundation of preventive medicine. It should scarcely be necessary to insist upon the necessity, in the prevention of disease in the military establishment, of requiring troops to avoid such material, persons, localities or structures as have either certainly or presumably undergone contamination by infectious matter. In the military service, the chances for the propagation of disease through the medium of infected articles are proportionately much smaller than in civil life, while persons sick with known contagious affections are instinctively shunned by all classes alike; but habitations, particularly in

time of war, are liable to be utilized for shelter by troops without proper investigation of their antecedents—the considerations of present comfort for the time outweighing the sense of possible future misfortune. Such a tendency to sanitary error, on the part of both officers and men, is always to be repressed. Should it at any time appear desirable to occupy buildings not under government control, or such barracks or other structures as may have been deserted by an enemy, it should be ascertained in advance if cases of contagious or infectious disease have occurred or have been sheltered therein; and if so, what measures looking to disinfection have been carried out. On such subjects, general information will be frequently unreliable and misleading, and hence the necessary inquiry should preferably be addressed to such competent local authority as may be able to answer correctly and without prejudice. A building which is ascertained to have contained contagious cases should always be viewed with suspicion, and, if it has not been properly disinfected, should under no circumstances be occupied—even temporarily. If near a camp, and hence a constant menace to the health of the command, such a building should either be guarded against entry by troops, be properly disinfected or destroyed by fire.

Abandonment.—As foci for the dissemination of infectious disease are always to be removed from a military force, so also the removal of such military force from a locality which appears to have become thoroughly impregnated with infectious material becomes imperative. This procedure must be carried out without delay. Removal to even a comparatively short distance is frequently sufficient to cut short serious outbreaks, particularly with regard to yellow fever, malaria and dysentery. If possible, the site selected for the new camp should present such conditions of altitude, soil, moisture and surface configuration as are recognized as being unfavorable to the development of the causative agents of the affection which it is desired to escape. In abandoning an infected encampment, all tentage and spare equipment should be left behind for careful disinfection. The men should be required to bathe immediately before deserting the camp; and such disinfection of the person and clothing as may be feasible should be prescribed. If the movement be to another camp of an intended semi-permanent character, the latter is best prepared in advance for the reception of the troops. The sick and all cases of a suspicious character must be rigorously eliminated prior to the departure of the command, and under no circumstances should they be permitted to accompany it on the march or follow later to the new camp.

Provided there be justifiable reason for belief that the infection is so localized that its destruction in this way can be properly accomplished, a practice march of ten days, the troops living in shelter-tents meantime, will afford an excellent opportunity for the application of radical measures of disinfection throughout the temporarily deserted post or encampment.

Troops among whom infectious disease is epidemically prevailing, should move camp frequently but should not continue on the march. Fatigue is a marked factor in lowering vital resistance and so directly predisposing to infection; besides which there would always be the probability of distributing the germs of disease along the route traversed by the command.

The scattering of the men in small groups over a wide area constitutes

an excellent means of breaking up and controlling epidemics of disease among large bodies of troops.

Individual Hygiene.—As regards the individual, prophylaxis is largely hygienic in its nature, and its aims are toward the production or maintenance of such a standard of bodily health as will best resist invasion of the organism by disease. As already stated, infectious germs do not possess the power of unconditionally entering the economy and disturbing its functions. For the production of disease there must be invasion by the special pathogenic micro-organism, together with circumstances permitting its subsequent existence and perpetuation. Hence the maintenance of health-giving principles, the results of which are manifested in increased vital resistance, is the great object of prophylaxis. The latter purposes to secure this object by suitable hygienic measures, and at the same time to remove or modify, so far as it may be possible, all unfavorable and debilitating conditions of environment.

The health of the individual is powerfully affected by the conditions under which existence is maintained, although predisposing causes of disease may also be present within the organism itself. As a result of surroundings, the struggle for existence may be of no great severity, but, on the other hand, they may render the maintenance of life extremely precarious. Care devoted to the improvement of environmental conditions in the military service is well repaid by greater efficiency, and every attention should be given to secure an excellent quality of clothing, proper ventilation, cleanliness and freedom from dampness of the habitation, personal cleanliness and a sufficiency of physical exercise.

Susceptibility to disease varies inversely with the standard of nutrition, and prolonged famine is always followed by pestilence. Hence the prevention of disease in the individual will largely depend upon the careful observance of all such measures as are calculated to assist in the nourishment of the organism. In time of epidemic, or when such an outbreak threatens, the food supply should be especially varied, abundant, nutritious and stimulant. Special articles of diet, appetizingly prepared, should be issued without particular regard to an increased drain on the company fund, since no financial outlay for such a purpose can compare with the cost of an outbreak of epidemic disease in a large body of troops. Excesses of all kinds, particularly those of an alcoholic nature, should at such times be carefully avoided.

It has repeatedly been demonstrated, both by practical experience and laboratory experiment, that prolonged and excessive fatigue exerts a markedly depressing effect on the resistive powers of the organism against disease. Foreign sanitary officers have long noted an increase in typhoid fever and other affections following the arduous exertion incident to the annual military manœuvers—an increase which they regard as only partially due to the temporary exposure to unusual sources of infection. It is evident, therefore, that during the unusual prevalence of sickness, and particularly in the presence of an epidemic, all drills and fatiguing exercises should be reduced to the practical minimum; without, indeed, actually condemning troops to that state of *ennui* and inactivity which in itself may be a strong predisposing factor in the occurrence of disease.

Since the mental state exerts a marked effect upon the physical condi-

tion, the spirits of the men should be sustained in every way through healthful amusements and recreation. Sanitary regulations specially applicable to existing conditions are to be duly brought to the notice of the command, but not in such a manner as to excite unnecessary apprehension. The observance of a quiet, calm demeanor on the part of officers, during time of epidemic, is all that will be necessary to insure the maintenance of a similar condition on the part of the men. Above all things, a condition of mental depression or panic is to be avoided.

It should never be forgotten by the sanitary officer that, in carrying out precautionary measures against disease among troops, the chief obstacle to success is found in the carelessness and ignorance of the soldiers themselves.

Artificial Immunization.—This means of prophylaxis has already been touched upon, in certain of its details, in connection with several of the infectious diseases common among soldiers; and it is obvious that no general discussion of this many-sided and as yet largely undeveloped subject can be taken up in a work of this special character. There is little doubt, however, that the military sanitarian of the future will find in protective inoculation, as with vaccination, one of his most potent aids in the prevention of infectious disease among troops. Much has already been accomplished along these lines, and there is abundant authority for the statement that "the problems relating to immunity have been, in part at least, removed from the realm of pure hypothesis and placed in a position favorable to exact experimental solution."

II.

DISEASES LARGELY DEPENDENT UPON EXPOSURE.

Bronchitis.

This affection, in our army, is one of the most frequent causes whereby soldiers are rendered temporarily incapacitated for duty. Its mortality in young men of the military age, when occurring idiopathically, is, however, small. In the United States service, the admissions for bronchitis, since the year 1860, underwent a certain decrease during the period of peace but were raised by field service, being as follows:

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1861–66	92.94	1895–98	75.48
1868–84	77.73	Year 1897	59.72
1885–94	68.67	Year 1898	100.65

Bronchitis may be brought about by a great variety of causes. There are those who regard it as largely due to an invasion of the respiratory tract by some specific micro-organism as yet undetermined, and any irritant gas or dust may produce it. In the military service, however, the evidence is conclusive as to the chief part in its origination being played by exposure and cold, particularly the latter. Reports for our army have for many years shown its greatest prevalence to occur in the more northern military departments and stations; and the remarkable influence of cold weather in inducing this affection, as determined by months, is well shown in the accompanying diagram. It would seem to be abundantly demonstrated

that, for our army, idiopathic bronchitis chiefly results from exposure to cold; this interrupting the eliminative functions of the skin, whereby an increased duty is thrown on the pulmonary mucous membrane, with its resulting congestion. This hypothesis largely explains the commonly observed fact that outbreaks of considerable magnitude not infrequently occur among bodies of troops, which are naturally exposed to the same meteorological and environmental conditions. Age is a factor of great importance in the occurrence of the disease, very young and very old soldiers being par-

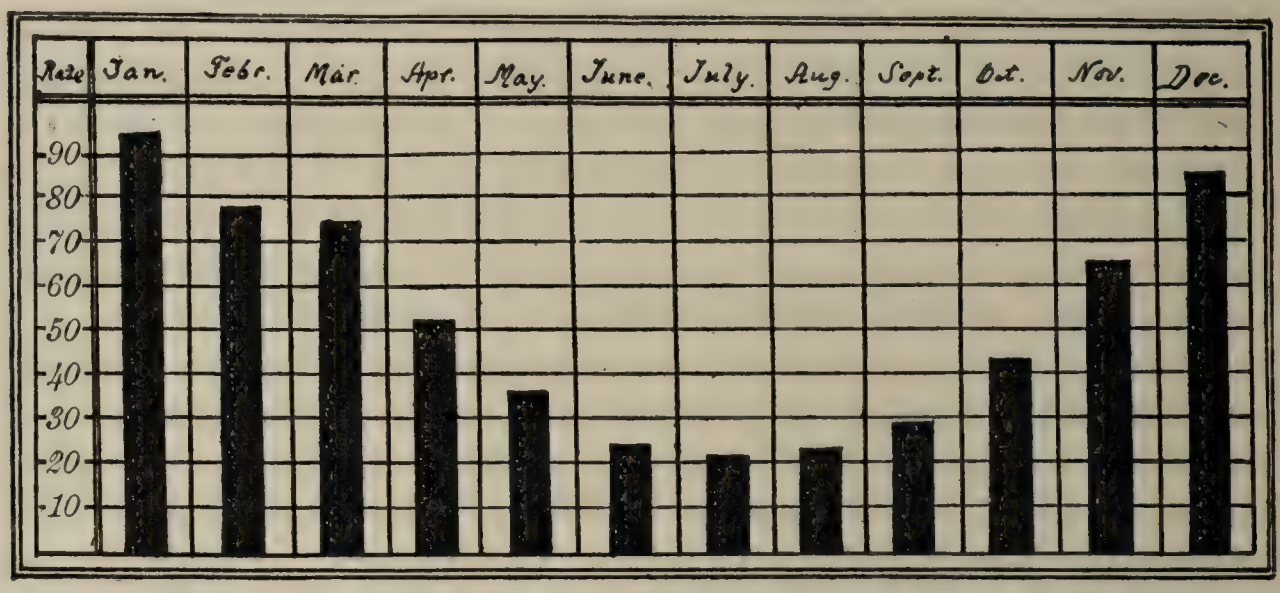


FIG. 355.—Monthly Rates of Occurrence of Bronchitis, per Thousand Strength, for the United States Army, during the Decade 1875–84.

ticularly liable to it. For the period 1890–96, figures showing the distribution of bronchitis, according to age, are as follows:

Age.	Admissions per 1,000 of each class.	Age.	Admissions per 1,000 of each class.
19 and under	132.08	40 to 44 inclusive	60.52
20 to 24 inclusive	83.70	45 to 49 "	61.39
25 to 29 "	60.66	50 to 54 "	70.75
30 to 34 "	57.15	55 to 59 "	88.60
35 to 39 "	53.98		

The greater exposure incident to mounted service explains the higher rates, for the above seven-year period, given by cavalry, 76.08 per thousand strength, as compared with infantry, 63.18 per thousand strength. The same condition also explains the greater frequency of this affection among troops in the field as compared with those in garrison; the proportion of cases during the year of war, 1898, being almost twice as great as during the year of peace, 1897. In many instances, wetting of the person, where an early cutaneous reaction is not secured, is followed by bronchitis. In barracks, this affection often appears to be directly associated with the use of an excessive quantity of water for the cleansing of floors and the damp atmosphere thus produced—though sometimes the opposite appears to be the case, as when an insufficient amount of moisture is imparted to the air of an artificially heated room, the suspended particles of dry dust being particularly irritant to the respiratory tract under such conditions.

In the prevention of idiopathic bronchitis, the avoidance of surface chilling, whether from insufficient protection, draft or wetting, should be avoided. Wet clothing should be replaced by dry garments as soon as possible, the body being wiped and rubbed vigorously to restore capillary

circulation. The barracks should be dry, warm and well ventilated without being drafty. The clothing issued should be of good quality and suited to the climate and season; more than that, its proper use should be enforced, and soldiers should not be allowed to go from a warm barracks into a cold, damp atmosphere without donning additional protection or seeing that their outer garments are well buttoned up. On guard, especially in wet or foggy weather, it is important that the person be well protected. When men are wet and chilled from exposure, the issue of hot soup or coffee is desirable. During a march in cold or wet weather it would seem that mouth-breathers are more liable to contract the disease. As far as possible, duty which implies exposure to inclement weather should be avoided. There is no doubt that troops long in the field, and habituated to exposure, are less liable to contract bronchitis than are new troops subsequently brought under the same conditions.

Rheumatism and Myalgia.

Under this heading are included, in our official nomenclature, all affections of a rheumatic nature not specifically diagnosed as rheumatic fever. Until 1884, rheumatic fever was also included in the figures for rheumatism in general, and hence statistics for muscular rheumatism are not satisfactory prior to that year. These affections are responsible for a large amount of inefficiency and loss of service; notwithstanding the fact that many such cases, through their insignificance, receive treatment and are returned to duty without being taken up on sick report. On the other hand, it is probable that the rates for subacute rheumatism and myalgia are unduly raised by fraud, since these conditions are the ones most frequently selected by malingerers for simulation. Since 1884, the admissions to sick report for these affections, per thousand strength, have been as follows:

Period.	Admissions.	Period.	Admissions.
Decade 1884–93	83.34	Year 1896	79.33
Year 1894	63.33	Year 1897	65.12
Year 1895	64.08	Year 1898	72.88

While the cause of these affections is unknown, they are markedly influenced in their frequency by moisture and, to a less degree, by cold. They attain their maximum prevalence among troops in this country in early spring and late fall, coinciding with the periods of greatest rainfall. In their geographical distribution, they are highest in those military departments in which the humidity is great; in posts, those in which damp casemates and old badly constructed barracks are in use.

Among our troops, the negro soldiers appear to be far more prone to affections of this character than are the whites, the rates for these two classes being as follows:

Year or Period.	Admissions per 1,000 white soldiers.	Admissions per 1,000 negro soldiers.
1884–93	79.68	121.60
1894	62.87	72.87
1895	61.40	95.07
1896	75.79	117.74
1897	61.80	100.74
1898	68.28	132.81

The great difference shown by the above figures is even more noteworthy when it is considered that the negro troops have, during the above period, been stationed in the western military departments in which, for white soldiers, these affections are of relatively infrequent occurrence. The latter occur more frequently among young soldiers than among those of somewhat longer service, probably through greater carelessness with regard to exposure. In the class of very old soldiers the rate is, however, high.

In the prevention of subacute rheumatism and myalgia, dryness of person and surroundings appears to be of by far the most importance, as is well shown in the previous section devoted to a consideration of casemates as habitations. Wetting of the person should, as far as possible, be avoided, and damp clothing and bedding should be at once removed and dried. Clothing which has been rendered repellent to moisture by the use of lanolin should be issued; and all clothing should be sufficient and adapted to climate, season and weather. Barracks should be warm, dry and well ventilated, should have a sunny exposure and be located on a dry site. The use of casemates as quarters for troops is to be vigorously opposed. When rheumatism and myalgia largely prevail in a post or barracks, a general inspection as to dryness of cellars and foundation walls is indicated.

Acute Articular Rheumatism.

Figures with regard to the prevalence of acute articular rheumatism in the United States army are not comparable for the period prior to 1884 with the period subsequent to that year, for the reason given in the preceding section. Since 1884 the differentiation of rheumatic fever has been required; and since that year the admission rates for acute articular rheumatism have been as follows:

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1885–94	5.10	Year 1897	4.36
1895–98	5.26	Year 1898	7.03

These rates for acute articular rheumatism are much lower than those of nearly all foreign armies. In the German army, the occurrence of this disease has been as follows:

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1881–82 to 1885–86	9.2	Year 1895–96	7.7
1886–87 to 1890–91	9.8	Year 1896–97	6.8
1891–92 to 1895–96	8.9		

In the Austrian army, the rates for acute articular rheumatism appear to be higher than in any other service, having been as follows during the past few years:

Year.	Admissions per 1,000 strength.	Year.	Admissions per 1,000 strength.
1893	11.3	1896	10.4
1894	12.2	1897	9.2
1895	11.6		

The true nature and origin of acute articular rheumatism are still unknown. Taking into consideration the many forms in which the disease

manifests itself, it is certain that no neurotic theory and no hypothesis of perverted metabolism can fully account for all the phenomena presented, many of which strongly suggest a microbic infection. No micro-organism has as yet been shown to be the cause of rheumatism; but the same is true of such undoubtedly microbic diseases as measles, scarlet fever, whooping-cough and syphilis. The strongly marked hereditary predisposition to rheumatism causes no difficulty, for the same fact is observed in tuberculosis. That exposure to cold and wet is often a factor in the causation of a rheumatic attack is analogous to what is often observed in pneumonia. Exposure, however, is a factor of such importance in the occurrence of rheumatism that, in default of accurate information as to its cause, the disease is most conveniently classed in this connection with those induced by cold, wet, dampness and exposure. Rheumatism has a certain relation to season. Coustan showed that for the French army the amount of rheumatism was much greater during the winter months than in spring or summer; in autumn, rheumatism was only about one-third as prevalent as during winter. Local conditions, as shown by figures for our army, appear to have far more to do with the occurrence of rheumatism than geographical considerations. Race exerts a certain influence; the admissions for this disease being lower for white troops than for colored troops. Age is a factor of some importance, the rates for the seven years 1890–96, per thousand strength, being as follows:

Age.	Admissions per 1,000 of each class.	Age.	Admissions per 1,000 of each class.
19 and under	8.61	35 to 39 inclusive	4.26
20 to 24 inclusive	5.71	40 to 44 "	5.01
25 to 29 "	4.11	45 to 49 "	5.58
30 to 34 "	4.06		

There appears to be no great difference, according to the branch of service, as regards liability to rheumatism. Exhaustion and chilling—especially wetting—often appear markedly to favor the disease; but it undoubtedly at times happens that regiments are long exposed to damp, wet, cold, sudden and violent changes of temperature, and are obliged to sleep on wet ground with but scanty protection, yet no cases of acute rheumatism follow. The disease appears to be much less prevalent in garrison than in the field; when it occurs in garrison it would seem that the causative agent finds its most favorable field for development in damp, badly-aired barracks and casemates—and the same applies to damp bedding or clothing. Recurrent attacks of rheumatism may perhaps be fresh infections or they may be caused by renewed activity on the part of germs lying quiescent in some part of the organism, as with tuberculosis. As the individual who has been infected with syphilis is always syphilitic, so it may be that the soldier who has once suffered from rheumatism may be permanently rheumatic, and temporary diminution of the powers of vital resistance by chilling may suffice to produce an acute recrudescence.

It is evident that, in the absence of knowledge as to the etiology of rheumatism, it is difficult to formulate any definite plan for its prevention. As a matter of the first importance in reducing future rates for rheumatism, it would be desirable that all those affected more than once with the disease should be eliminated from the service. Much may be done toward

preventing the development of rheumatic attacks by providing dry, sunny barracks, by frequent exposure of bedding and clothing to the sun, the prompt changing of wet garments and, in the field, the location of camps on well-drained sites and care in keeping the men above the surface of the ground while asleep. A sufficiency of clothing, especially of woolen material, is of importance.

III.

DISEASE PRODUCED BY AN IMPROPER DIETARY.

Scurvy.

Occurrence.—Scurvy, from time immemorial down to a comparatively recent period, has been the scourge of armies, especially during campaign. In the thirteenth century, scurvy ravaged the hosts of the Crusaders—and since that time it appears to have been almost continually present during active military operations until within the last score of years. Instances of its epidemics could be multiplied almost indefinitely. At Thom, in 1703, during the Spanish siege, 6,000 men died of scurvy. During the Napoleonic wars it crippled the efficiency of the French troops in Egypt; in 1801, and in 1807 and 1808, it ravaged the garrisons in Prussia. In the war of 1812 it was noted as being very prevalent among our troops; and Rosse states that among 1,016 United States soldiers marching to and garrisoning the post of Council Bluffs, in 1820, there were 516 cases of scurvy and 168 deaths from this cause. The disease occurred among our troops, to some extent, during the invasion of Mexico; and for the eighteen years prior to the outbreak of the Civil War the admission rate for scurvy was 26.3 per thousand strength. During the Crimean War, 23,365 cases occurred in the French army, the Turkish force was almost destroyed by it, and the cases in the British army amounted to 17,557. In the various hospitals at Constantinople, according to Marvaud, there were treated, in 1855, no less than 14,879 cases of scurvy, of whom 1,407 died; in 1856 there were 10,295 cases with 1,509 deaths. It prevailed among our troops during the Civil War, and its recognition was a surprise and shock to professional ideas preconceived from practice in civil life. In spite of all effort to the contrary, there were 46,913 cases of this disease in the Union forces during the period 1861–66, giving an admission rate of 19.80 per thousand strength. There were 771 deaths directly ascribed to scurvy during this period, but no record of its well-known influence in bringing other diseases to a fatal termination was obviously to be made. After the conclusion of the Civil War, it prevailed to a great extent among our troops serving at frontier stations; there being 887 cases in 1868 and 211 cases in 1869. There were 115 cases in 1871; after which the rates for this disease fell rapidly on account of the greater facilities afforded troops for procuring vegetables—both through better means of communication and from the gardens which were gradually established at military posts. In the first few years after the Civil War, there were several minor outbreaks of great severity.

During the Franco-Prussian War, while the number of cases of scurvy was not great, a general scorbutic tendency was thought to have done much

to increase the mortality among the troops. Rosse states that in the Russian army, in 1873, the number of cases of scurvy amounted to 53 per thousand. In the Russo-Turkish War of 1878 it was present in both armies. In our own service, for the decade 1885–94, there were 27 cases, of which 18 occurred in 1888 and 5 in 1889. From 1892 to 1898, inclusive, only 1 case was reported. The addition of an abundance of fresh vegetables to the ration, in 1890, was undoubtedly most potent in removing the scorbutic predisposition previously existing among our troops. In the British service, in spite of all precautions, a few cases of scurvy are constantly present; particularly among troops in India, in which the rate of admission was 7.4 per thousand for the decade 1887–96. The admissions for the decade 1888–97, for the entire British army, amounted to .4 per thousand. In the German army, in 1897, there were reported 74 cases of scurvy and purpura. Coustan states that in the French service a number of minor outbreaks have lately occurred among troops stationed in Algeria. For the Russian and Austrian armies, the rates of admission for this disease, per thousand strength, have lately been as follows:

Year.	Russia.	Austria.
1892	1.7	1.7
1893	1.9	2.3
1894	1.7	1.2
1895	1.5	1.4
1896	1.3	1
1897	1.2	1

Through a better knowledge of its etiology, scurvy is now quite rare among troops. Its insidious character, however, favors a possibly unnoted invasion, its frequency renders it unfamiliar and the very knowledge of the efficient means possessed for its prevention gives a false idea of security. It is a mistake to regard scurvy as being attendant solely on the unhygienic conditions of past centuries, long voyages, famine diets or special cases of privation. The dyscrasia for troops in the field is rather to be regarded as merely latent and requiring but a temporary interference with the distribution of supplies, and a brief subjection to depressing influences, to render its existence apparent—though not necessarily in the aggravated form with which the continued action of its cause characterized it in former times. The imminence of scurvy, under any circumstances where a proper nutritive standard is departed from, should be fully appreciated by the sanitary officer.

Cause.—Scurvy is due to an ill balanced dietary in which fresh vegetables and their salts are deficient. Salt meat—and fresh meat which has undergone putrefactive changes, but is still eatable—is considered to favor the occurrence of scurvy. As predisposing causes, excessive fatigue and overcrowding of quarters may be mentioned. Cold and humidity are also powerful factors, although scurvy is by no means uncommon in warm climates. Besides these, depression of spirits, nostalgia and lack of exercise play no unimportant parts. As illustrating the latter point, an instance is recorded where a number of prisoners of war were removed on board ship and fed on exactly the same diet as those on shore. The men on shipboard contracted the disease—the prisoners on shore did not.

Scurvy, occurring in the military service, usually at once assumes an epidemic character, through the fact that large numbers of men are generally at the same time exposed to the conditions to which the disease owes its origin. From this fact, scurvy was long thought to be contagious. The disease has great respect for military rank and rarely occurs in officers; a fact due to their better nutrition and lessened exposure to depressing conditions. It has a marked tendency to occur in convalescents, and may frequently be associated with other diseases, to whose attacks it imparts additional severity. In the Crimean War, typhus which had occurred in a scorbutic patient was said to have been uniformly fatal. Winter is particularly the season when scorbutic manifestations appear; this being the season when fresh vegetable material is scarce and troops are largely confined, through the inclemency of the weather, in the vitiated air of their quarters. Sometimes scurvy occurs in the autumn. This was the case at the Crimea, when 500 cases occurred among the French troops during a period of three months.

While the symptomatic diagnosis of scurvy is not a subject for discussion in a work of this character, it may be here remarked that scurvy is usually seen, by medical officers, in the early stages, at which time it not infrequently simulates muscular rheumatism and is liable to be mistaken for the results of simple exposure to wet and cold. The characteristic symptoms of the disease are later manifestations. Among the conditions not infrequently present as a result of scorbutus are acrodynia and hemeralopia or night-blindness. Both have prevailed epidemically in armies. Hammond noted the presence of hemeralopia among our troops in Kansas and New Mexico, and even as late as 1884 it figured in the army returns. During the Crimean War, both French and English suffered from this affection, and after the capture of Sebastopol the number of hemeralopics was said to have been so great in the French army that certain regiments could not furnish the necessary number of men to mount guard. The condition has repeatedly been caused to disappear by improvement in the character of the food supplied. In this connection, mention may be made of ulcerative stomatitis; which, formerly common in armies, is now rare. This affection undoubtedly depends upon a scorbutic tendency and lowered powers of resistance resulting from malnutrition. Coustan mentions nineteen epidemics of it as having been recorded in the French army between the years 1793 and 1877.

Prophylaxis.—Scurvy is an entirely avoidable affection and its existence is a reproach to the supply and sanitary departments. The disease would rarely occur if the character of the food supplied corresponded with the natural cravings of the individual, and it is only where the use of a restricted and improper diet is required that its occurrence is possible. At the present day, its existence is evidence of lack of efficient sanitary administration, defective transportation or short-sighted economy—all being inexcusable.

Scurvy may be prevented by the administration of citric, tartaric, malic, acetic and lactic acids or their salts. These are best given in the juices of fresh succulent vegetable material; fresh fruits, tubers, roots and leaves being better than seeds, while the leguminosæ—as beans or peas—have no antiscorbutic virtues. The raw potato, onion and tomato are especially valu-

able. Fresh cabbage is excellent, being better than sauerkraut, and radishes are also valuable. Where such vegetables can be obtained in abundance, scurvy will not appear. For troops in the field, the dandelion and "lamb's quarter" are frequently available and may be eaten as greens. The yellow mustard and cresses can be used as salad, while the young shoots of the poke-weed serve an excellent purpose as a vegetable. In some regions the so-called scurvy-grass, or cochlearia, will be found. Woodhull recommends the agave as an antiscorbutic. To prepare it, the leaves are cut off close to the roots and well cooked in hot ashes. The juice is expressed and taken, either raw or sweetened, in the proportion of one to four wineglassfuls several times daily. All the varieties of the cactus are useful, in the absence of other vegetable material, in the prevention of scurvy. After roasting, the succulent interior, though not always very palatable, is a valuable food. In general, fresh vegetable matter of any variety can be used with advantage, provided only that it has no harmful qualities. Made into soups, nearly all are tolerably palatable.

Wherever the authorized issue of vegetables is scanty, the supply should be increased, from outside sources, by every means possible; and, under any circumstances, post gardens should be maintained wherever practicable, from the excellent addition to the diet which they furnish. Dried vegetables are antiscorbutic, but much less so than the fresh; the vegetable acids being probably decomposed by heat and keeping. When the vegetables are desiccated and compressed, a considerable proportion of these acids and their salts are removed and what remains is too largely cellulose. It is said, however, that our forces in the expedition against the Mormons, in Utah, owed their preservation from scurvy largely to the use of desiccated vegetables, at a time when nothing else of an antiscorbutic nature could be obtained. The use of fresh vegetables should never be superseded by the preserved article when the former can be obtained. Fresh fruits, especially lemons, limes, grapes, oranges and acid fruits generally, are excellent antiscorbutics. Even unripe fruits are better than none, and diarrhœa may be hazarded, under certain circumstances, for the sake of their valuable properties. Dried and canned fruits are also of advantage. Preserved lime juice has been much used on shipboard in the prevention of scurvy; it has long been employed in the British army and navy, and forms part of the British field ration, in the proportion of half an ounce daily, in the absence of fresh vegetables. Excellent results have followed its use in this manner, and it could be adopted with advantage in our own service for similar conditions. Good beer and wine appear to have decided antiscorbutic value, and spruce beer has been made and used with benefit. Vinegar, one-half to one ounce daily, may be used for this purpose in the cooking or taken with pickles; it was much used as an antiscorbutic in the armies of antiquity. It has long been known that those who eat large quantities of fresh under-done meat, even though a limited amount of vegetable material is used, escape scurvy. This antiscorbutic quality of fresh meat is largely destroyed by cooking, probably through the splitting up under heat of the lactic acid which it contains. It is a matter of common observation that Indians and Esquimaux, who may eat no vegetable material for considerable periods but who habitually use meat, either raw or in a partially cooked condition, are not affected with scurvy—and

the same is true of whites who follow their example. At times when scurvy was prevalent in our western garrisons, the hunting parties sent out to procure fresh supplies, living largely on under-done flesh, were notably exempt from this affection. The value of raw meat as an antiscorbutic has been repeatedly noted by Hayes, Kane and other Arctic explorers. Kane wrote: "Had we plenty of frozen walrus I would laugh at scurvy." Pemmican, prepared with fat, sugar, raisins and currants, is an excellent antiscorbutic for cold climates and is much in vogue with travelers in the far north.

Where fresh vegetables cannot be obtained, the administration of the vegetable acids, especially tartaric and citric acids combined with an alkali, is highly desirable in the prevention or treatment of scurvy. Since the disease is favored in its occurrence by confinement, impure atmosphere, cold, dampness and mental depression, any unfavorable condition of this character should be remedied and every effort made to elevate the physical and mental tone of the soldier.

IV.

DISEASES LARGELY DEPENDENT ON MILITARY SERVICE.

Affections of the Circulatory System.

The influence of the conditions met with in the military service on the production of cardiac and vascular disorders has already been touched upon to some extent in connection with the subjects of marching and the carriage of the equipment.

That affections of the heart and circulatory system are more frequent among soldiers than in the corresponding class in civil life there can be no doubt; thus, according to Rosse, aneurism is eleven times more common in the British army than among the civil population from which it is recruited. These cardiac and circulatory affections appear to be largely dependent upon the great mental and physical strain undergone by marching troops during active campaigns; the overburdening of the soldier and the carriage of excessive weight by vicious apparatus, by which the action of the vascular system is mechanically interfered with; the possible influence of poor food and exposure to inclemencies of weather; the nervous strain to which the recruit is subjected during his metamorphosis into the soldier; the insidious influences of venereal disease and of the excessive use of strong tobacco and stimulants.

As showing the important influence which the character of service exerts upon the occurrence of cardiac and vascular disease, statistics for our army for the seven-year period 1890–96, showed the admissions to sick report for these affections, per thousand strength, to be 6.98 for infantry, 6.53 for artillery—who are largely drilled as infantry—and 4.95 for cavalry. The soldiers of the Ordnance and Medical Departments, who are not required to perform arduous drills or carry heavy weights, and who rarely use the regulation blanket-bag carrying apparatus, presented rates of but 4.35 and 3.70 respectively during the same period.

Race also exerts a considerable influence on the occurrence of cardiac and circulatory affections; the admission rates for white and colored troops, per thousand strength, for the decade 1888–97, being 5.91 and 4.31 re-

spectively, while that for our Indian soldiers was but 2.20 for the same period. This influence of race in the production of heart disease is very evident among the native and European troops of the British forces in India. Moore gives the following comparison, in this respect, for the year 1895:

Race.	Number of troops.	Admissions per 1,000 strength.	Discharges per 1,000 strength.	Deaths per 1,000 strength.
European troops	71,031	2.16	0.90	0.15
Native Indian troops	129,211	.24	.07	.09

Thus among the European troops the death rate was twice, the admission rate nine times and the rate of discharges for disability from cardiac affections twelve times as great as among native troops. Among the white race, certain nationalities appear to be more predisposed to cardiac disease; among the soldiers of our own service, for the period 1890–96, the admissions for this cause, per thousand of each class, were as follows:

American-born	4.71	Germans	5.19
English	5.13	Irish	5.34

Climate also exerts an influence of no small importance in this respect. Thus, in 1899, the admission rate for circulatory diseases was 8.72 for the tropical islands and 6.14 for troops serving in the United States. That this difference was not due to the more active service in the Philippines is shown by the fact that the rate of admissions for those islands, 8.38, was smaller than for the troops in Cuba, 9.27, or those in Porto Rico, 9.39, during the same period.

Age also has a considerable effect on the figures for cardiac disease, very young and very old soldiers being particularly liable to such affections. Thus for the period 1890–96, the admission rates in our service, per thousand of each class, were as follows:

Age.	Admission rate.	Age.	Admission rate.
19 and under	9.33	35 to 39 inclusive	3.51
20 to 24 inclusive	5.94	40 to 44 "	6.58
25 to 29 "	4.15	50 to 54 "	8.30
30 to 34 "	3.70		

In the German army the rate of admission for cardiac disease is exceptionally low.

Period.	Admissions per 1,000 strength.	Period.	Admissions per 1,000 strength.
1881–82 to 1885–86	1.5	Year 1894–95	2.9
1886–87 to 1890–91	2	Year 1895–96	3.2
1891–92 to 1895–96	2.8	Year 1896–97	2.9

In the Russian and Austrian armies, the rates differ but little from those for our own service.

The prophylaxis of cardiac and vascular disease, so far as it can be accomplished, is obvious from the points which have just been considered. The best opportunities for improvement would seem to lie in the lightening of the burden at present transported by the soldier, the adoption of a rational apparatus for the carriage of such burden, the avoidance of overexertion and too hard marching, the rejection of immature recruits and care not to overtax the powers of such as have been accepted for service.

CHAPTER XVI.

DISINFECTION.

DISINFECTION, essentially aggressive in character, aims at the destruction of the specific causes of infectious and contagious disease at the points of their origin and existence outside the structure of the living organisms which may from time to time become their hosts. In its processes, disinfection is no longer a vague attempt in some way to influence the unknown, as instanced by the scattering of powdered sulphur and the building of bonfires during epidemics in mediæval times, but is now carried out in accordance with carefully elaborated scientific methods based upon amply demonstrated facts in the life history of the pathogenic micro-organisms concerned. Sanitary science is no longer dealing with the indefinite and mysterious, but has to do with living pathogenic entities which are known to respond in every way to changes of environment as do the more highly organized forms of animal or vegetable life. Disinfection purposes to attack these morbific agents at the points where they are developed and from which they may be disseminated. It aims at nothing less than absolute destruction wherever possible; but must in practice, under some circumstances, be content with creating an environment unfavorable to the extended propagation of the micro-organism, and while limiting its growth perhaps also modifying its character as regards toxicity and virulence. As it has for its object merely the destruction of pathogenic bacteria, infected articles or places may be deprived of their noxious qualities without resorting to their actual disuse or destruction.

As defined by the Committee on Disinfectants of the American Public Health Association, a disinfectant is "an agent capable of destroying the infectious power of infectious material." With this definition in mind, the terms "disinfectant" and "germicide" become practically synonymous. Disinfection thus implies completeness of both action and result, since an object on which only a portion of the micro-organisms has been destroyed is evidently not disinfected. "There can be no partial disinfection. Either the infecting power is destroyed or it is not." As both pathogenic and saprophytic micro-organisms are usually destroyed by the same processes, the terms "disinfection" and "sterilization" may, for all practical purposes, be considered as expressing the same condition.

An antiseptic is a substance which may have no true germicidal powers but which is capable of impairing the vital activity and inhibiting the propagation of micro-organisms. An active disinfectant, when present in great dilution, may hence become an antiseptic. A deodorant is a body possessing the power of destroying odors, but is not necessarily either an antiseptic or a germicide. A single substance, however, like chlorine or formaldehyde, may possess both deodorizing and disinfecting properties.

The germicidal power of the same substance varies greatly when ap-

plied to different micro-organisms. Hence, in testing the value of disinfectants all experiments should be applied to such as are most resistant; certain spore-forming bacteria being much more difficult to destroy than other varieties. Old cultures are in general more readily sterilized than those of recent growth, but pore-forming bacilli are better destroyed at an earlier period in their development; an acid medium restrains the growth of many kinds of bacteria. All micro-organisms, when dry, are much more resistant to attempts at disinfection than when in a moist state. Elevated temperature in general favors the action of disinfectants; whatever be the disinfectant employed, it should be brought into contact with the germs to be destroyed at as high a temperature as possible. For the same germ, the resistance varies with its age and development, the degree of humidity, reaction of the culture medium, temperature and other conditions of environment.

DISINFECTION BY PHYSICAL PROCESSES.

Desiccation.—All living micro-organisms are sooner or later attenuated in their pathogenic activities, and are finally killed, by drying. With the non-sporulating species, and particularly certain of those possessed of disease-producing powers, this effect is at times conspicuously manifest. With the spores of spore-forming bacteria, however, drying requires a much longer time to attenuate and a still longer time to kill them. Fortunately only a small proportion of the known disease-producing bacteria form spores, so that desiccation, even such as occurs with the ordinary environment of pathogenic bacteria outside the body, is of much importance in preventing their development and ultimately in destroying their vitality. Thus the spirillum of Asiatic cholera, when dried, dies in from three hours to two days, according to the degree of desiccation; the bacilli of typhoid fever, tuberculosis and diphtheria resist drying for a longer time but gradually lose their vitality. The influence of drying in checking the multiplication of bacteria—for none of them develop in a dry state—is of manifest importance in connection with the spontaneous elimination of infective diseases.

That the habitations and surroundings of the soldier should be kept in a state of dryness is clearly essential in the maintenance of health. This is particularly important in the case of troops under canvas, and especially so in camps of more or less permanency. Under such conditions the thorough dryness of the tent site, together with that of the bedding and clothing, should be uniformly secured in the prevention or restriction of epidemic outbreaks. The frequent hanging up of bedding and clothing in the open air, except during stormy weather, secures the desired dryness; and in addition the oxygen of the air exerts a destructive effect upon such micro-organisms as may be harbored on these articles, while the agitation to which they are subjected by a strong breeze not only mechanically dislodges and removes a considerable proportion of the adherent micro-organisms but also markedly interferes with the development of those of certain species. Melzer, Hanson and others have found that violent and long-continued shaking was quite fatal to several varieties of bacteria.

Sunlight.—A large proportion of the sporeless pathogenic bacteria are

killed by the direct rays of the sun, as has already been mentioned in connection with the subjects of water and the sanitary administration of camps. In laboratory experiments this effect is very striking, many species being destroyed in the presence of sunlight and air in so short a time as one or two hours. Diffuse daylight, as noted in relation to the lighting of barracks, is also detrimental to pathogenic micro-organisms, though its action is much less energetic than is that of direct sunlight. Buchner has shown that the bacillus of typhoid fever is destroyed in from one and one-half to two hours by the direct solar rays, and in five hours by diffuse daylight. The diphtheria bacillus is destroyed by from one-half to one hour's exposure to direct sunlight; while Koch found that the tubercle bacillus is killed by the rays of the sun in from a few minutes to several hours, according to the thickness of the mass exposed. Esmarch endeavored to turn these laboratory results to the benefit of practical disinfection; but after a thorough series of experiments he concluded that the disinfecting power of sunlight was observed only upon directly exposed surfaces, and here there were also inequalities in the results. The time required to obtain the best results was found to be somewhat long. As a result of his experiments he concluded that direct sunlight could not be uniformly relied upon to accomplish disinfection, but that exposure to the solar rays, particularly in connection with desiccation, nevertheless exerts an important influence in arresting the growth and activity of pathogenic bacteria.

From these facts it is apparent that habitations and their contents should be exposed as much as possible to the purifying influence of sunlight and fresh air. In the field, the looping up of the tent walls is of the first importance and should be carried out under orders on every fair day. All garments, blankets and bedding should be removed from the tent and suspended from one margin, not merely spread on the ground or on a tent roof. Wherever possible, clothes lines should be stretched in camps, running north and south so as to give free access of the solar rays to both surfaces, and clothes pins should be provided for fastening to these lines the articles to be exposed. The latter should not be placed sufficiently near each other to interfere with either the sunlight or air-currents of others. By this means the surfaces of articles, such as blankets, are efficiently sunned, desiccation by the solar heat and air-currents is secured and thorough agitation of the article is accomplished; the latter not only dislodging adherent micro-organisms but favoring the permeation of the meshes of the fabric by fresh air, and thus carrying the inhibitory influences of the latter below the directly exposed surfaces. Drying, sunning and shaking, however, cannot be relied upon for the disinfection of articles under all circumstances, and should not be used where positive results are to be secured. These agents, however, are possessed of undoubted value in inhibiting the growth of pathogenic micro-organisms and have a wide field of usefulness in connection with military sanitation.

Incineration.—For the destruction of infectious material, the most ready and certain method consists in the application of fire. The employment of this agent, however, is obviously to be confined to such articles as possess little if any value; since equally positive results may always be obtained by other methods, even if at the expense of a greater outlay of time and labor. For the disinfection of tuberculous sputum or the secretions

of the sick, or for the sterilization of such worthless material of an organic nature as may have become permeated by a morbific agent, the method of incineration should always be selected. Certain bulky articles, which are inexpensive and from their nature are with difficulty disinfected by ordinary methods, such as mattresses or pillows, are preferably to be burned. Whenever such action is taken, the employment of the stove or furnace is desirable; if destruction by fire be carried out in the open air, due care should be taken that combustion is complete and that small unburned particles carrying infectious matter are not scattered by the action of the wind. For thoroughness of incineration, saturation of the article with petroleum before ignition is advisable.

Dry Heat.—While the use of dry heat furnishes a possible method for the disinfection of small articles, it is one of such limited applicability, and in the absence of special apparatus its use is attended with such difficulty and uncertainty, that its employment as a matter of choice, under any circumstances, will rarely be justifiable. There is not an indication in the general process of disinfection which cannot be more readily and conveniently met by other well-known methods; while the length of time required for its execution, together with its destructive effect upon textile fabrics and similar articles, furnishes a standing argument against its employment.

With regard to dry heat, Koch found that an exposure of three hours at a temperature of 117° C. would not destroy all bacteria; while with bulky articles the outside was frequently scorched even at a time when the interior did not present a sufficiently elevated temperature to accomplish disinfection. Dry heat at 115° to 120° C. is not uniformly capable of destroying all micro-organisms, and exposure to a temperature of 140° C. for three hours, as required for the accomplishment of general disinfection, can scarcely be carried out on textures without injury to them of a greater or less extent. Scorching occurs at 120° C. with woolen substances—sooner than with those of cotton or linen—the change of color being often accompanied by deterioration of the tensile strength of the fabric. Dry heat causes little or no shrinkage of woolens; but, like moist heat, it results in the fixation of all stains of an albuminous nature. For disinfection by dry as well as by moist heat, the thorough penetration of the articles is necessary; this being greatly favored by the production of a partial vacuum.

In the absence of special apparatus for disinfection by dry heat, an ordinary oven may be utilized; but as the temperature of such an oven cannot be accurately controlled by the operator, the results obtained from its use will often be unsatisfactory.

Moist Heat.—All things considered, the best disinfectant is probably moist heat, since it is cheap, easily used and manipulated and is not liable to injure the great majority of articles to be disinfected. No discussion, in the light of present knowledge of disinfection by steam or boiling, is here required to demonstrate the efficiency of these processes, for the fact may be considered definitely settled and universally accepted.

Boiling.—Immersion in boiling water, like incineration, affords a simple, ready and efficient method for the destruction of infectious material. Its applicability extends to all articles of a metallic or earthen nature as well as to linen and cotton fabrics—but woolen or leather goods

cannot be boiled without undergoing considerable injury. Koch showed that boiling for five minutes in an alkaline solution was sufficient to destroy all pathogenic micro-organisms and their spores, while all but the most resistive were destroyed in two minutes. The boiling of infected articles in a two per cent. solution of sodium carbonate for a short period will not only readily accomplish their disinfection but will so loosen particles of foreign matter as to render their subsequent washing much easier of accomplishment.

Streaming Steam.—The use of streaming steam for purposes of disinfection gives excellent results in practice, although in theory the manner of its employment, as usually carried out, is not without imperfections. Very positive advantages in the use of this method are to be found in the fact that the apparatus required, though special in character, is inexpensive and that the technique of its operation is of the simplest nature. While fulfilling an excellent purpose in the sterilization of small articles, the method is scarcely applicable to objects of considerable bulk and hence possesses only a limited value for purposes of general disinfection.



FIG. 356.—Arnold Sterilizer.

Disinfection of bulky articles by the use of streaming steam requires a full hour for its accomplishment, while the same result may be attained in twenty minutes by the use of superheated steam. The period of disinfection should be reckoned from the time that steam begins to stream from the apparatus. Streaming steam has inferior powers of penetration; and larger articles, according to Laveran, when placed on the floor of the apparatus, will only with difficulty attain a temperature of 100° C. in their interior. As heated air constantly tends to rise, and since a cubic foot of steam at 100° C. weighs only 62.2 per cent. as much as the same volume of air at 100° C., it is evident that the temperature throughout the sterilizer will not be uniform and that the lower strata of air will be both cooler and less saturated with moisture than the upper layers. It is well, therefore, that the objects to be disinfected should be disposed in such a manner as to favor their permeation, and that the disinfecting process should be continued sufficiently long to ensure the complete success of the operation even under less favorable conditions. In an emergency, a simple but efficient apparatus for disinfection by the use of streaming steam may readily be improvised.

Of the various types of small sterilizers depending upon the use of free flowing steam for their efficiency, the Arnold sterilizer, as issued for use in the United States army, probably best meets all indications. In this sterilizer, water is poured into the pan or reservoir, whence it passes slowly through small openings into the shallow generator, becomes converted into steam

and rises through the tube in the center to the sterilizing chamber above. Here it accumulates at a temperature of 100° C.; the excess of steam escaping about the cover to become imprisoned under the hood and thus form a steam jacket around the sterilizing chamber. As the steam is forced down from above and meets the air it is condensed and returns as water to the reservoir. The sterilizer is best used on an ordinary stove, but no great amount of heat is required. The hood and lid should be removed as soon as the heat is diverted, to prevent condensation of the accumulated steam and the wetting of the articles which have been sterilized.

Superheated Steam.—Disinfection by steam under pressure appears to have attained a state of practical perfection. Koch found that superheated steam at a temperature of 110° C. destroyed anthrax spores in ten minutes; and this temperature, with an exposure of twenty minutes to an atmosphere saturated with watery vapor, may be confidently relied upon to accomplish the disinfection of any ordinary material or articles. In the British army an exposure for one hour to a temperature of 105° C. is officially required. The latent heat in steam accounts in a large measure for its greater germicidal efficiency as compared with hot air. As expressed by Notter and Firth, "to convert a certain amount of water at 212° F. into steam at 212° F. requires nearly one thousand times as much heat as it does to raise the same amount of water one degree, from 211° F. to 212° F. Conversely, a corresponding amount of heat is liberated with the condensation of steam at 212° F. into water at the same temperature. When an object is heated by being placed in hot, dry air, not only is no latent heat yielded up to it by the air but, on the other hand, before the object can attain the temperature of 212° F. any water which it may contain must be evaporated; in this evaporation heat passes into the latent form and the attainment of the desired temperature is thus delayed."

The production of a partial vacuum prior to steam sterilization is of great assistance in the carrying out of the process, since air is a poor conductor of heat and its removal permits the entrance of the steam to every portion of the articles to be disinfected. After a certain amount of steam has passed into the chamber, the air of the latter should again be exhausted before the actual disinfection. Superheated steam penetrates objects to be disinfected much better than free flowing steam. An internal temperature of 100° C. in bulky articles is readily reached under high pressure, even as small an elevation as one-twentieth of an atmosphere materially assisting in disinfection. The rapidity of the process depends in a large degree upon the internal pressure and hence the temperature; since it is important to know the internal temperature corresponding to the manometric readings of the high-pressure apparatus, the following table will be of value.

Pressure in atmospheres.	Temperatures.	Pressure in atmospheres.	Temperatures.
1.00	100.0° C.	1.66	115° C.
1.02	100.6	1.96	120
1.04	101	2.30	125
1.07	102	2.67	130
1.11	103	3.10	135
1.14	104	3.57	140
1.20	105	4.10	145
1.28	107	4.70	150
1.40	110		

Moist heat causes considerable shrinkage in all woolen fabrics; as well as a loss, through removal of the natural grease of the wool, of that elasticity and softness upon which its warmth to a considerable degree depends. Kratschner and Schafer found that woolen material, disinfected by steam under high pressure, underwent a slow chemical alteration which manifested itself in the liberation of fatty acids, sulphur and ammonia and in a certain diminution of tensile strength. Cotton and linen will bear exposure to moist heat at 118° C. for a sufficient time to effect disinfection without deterioration, but Levison found that after as many as ten sterilizations by steam the tensile strength of linen fabrics was considerably impaired. For all practical purposes, however, disinfection by superheated steam may be considered to have but little injurious effect upon fabrics; since the process must always be looked upon as unusual and rarely to be required in the military service, except in the case of hospital property, in more than a single instance for the same article. Wetting of woolen goods causes shrinkage and often some deterioration of color in articles of inferior quality. It is therefore desirable that objects placed in the steam chamber should be heated before the admission of the vapor, since, if this precaution be not taken, the resulting condensation of a large amount of steam will render them extremely damp. To avoid staining with rust, such articles as are undergoing disinfection by steam should not be allowed to come in contact with iron. Spots of blood, fæces or pus should be removed prior to disinfection by the use of moist heat, since otherwise they become indelible through coagulation of their albumen. Such spots may be removed by previous soaking in cold water, to which a little soda has been added; or they may be treated with a solution of potassium permanganate, the resulting rose color being subsequently discharged by the addition of oxalic acid.

An excellent type of the high-pressure steam disinfecting apparatus is the Kinyoun-Francis model, as adopted for use in the work of the United States Marine-Hospital service. In this apparatus the steam chamber is constructed of an inner and outer steel shell, forming a steam jacket. The doors are fitted with steam-tight gaskets and are handled by convenient cranes; being drawn tight by eye-bolts, swinging in and out of slots in the door frames. The chambers are rectangular in shape, to give the most effective space during exposure with the greatest economy of steam and to enable the cars to be readily handled in and out. The jacket gives perfect circulation, prevents too rapid condensation and thoroughly dries the goods exposed. This jacket is filled with steam during the entire operation, making the chamber a drying oven, so that the articles to be disinfected are brought to a high temperature before the admission of steam to the inner chamber and are thoroughly dried after the steam has been exhausted. To facilitate the penetration of the material to be disinfected, a vacuum is produced prior to the admission of steam to the inner chamber; the system of piping being so arranged as to give thorough control of the circulation. Steam may not only be admitted at the top or bottom at will, but may also be admitted at either end or on top and be discharged at the opposite end on the bottom, or vice versa; so that cross-currents are obtained and the steam handled in any manner suited to obtain the best results from the articles exposed. The chamber is pro-

vided with a galvanized hood, to prevent the steam from impinging directly upon the clothing; thermometers, to register the temperature; gauges, to indicate both vacuum and steam pressure, and safety-valve, to prevent over-pressure in the chamber; the amount of pressure being regulated by a reducing-valve in the steam-pipe from the boiler. For convenience of handling the goods, cars of light wrought-iron construction are provided, with removable trays, covered with galvanized screens and having bronze hooks at the top; thus permitting the articles to be laid out upon the trays or to be hung upon the hooks. The doors at both ends of the chamber allow the cars to be brought in at one end and removed at the

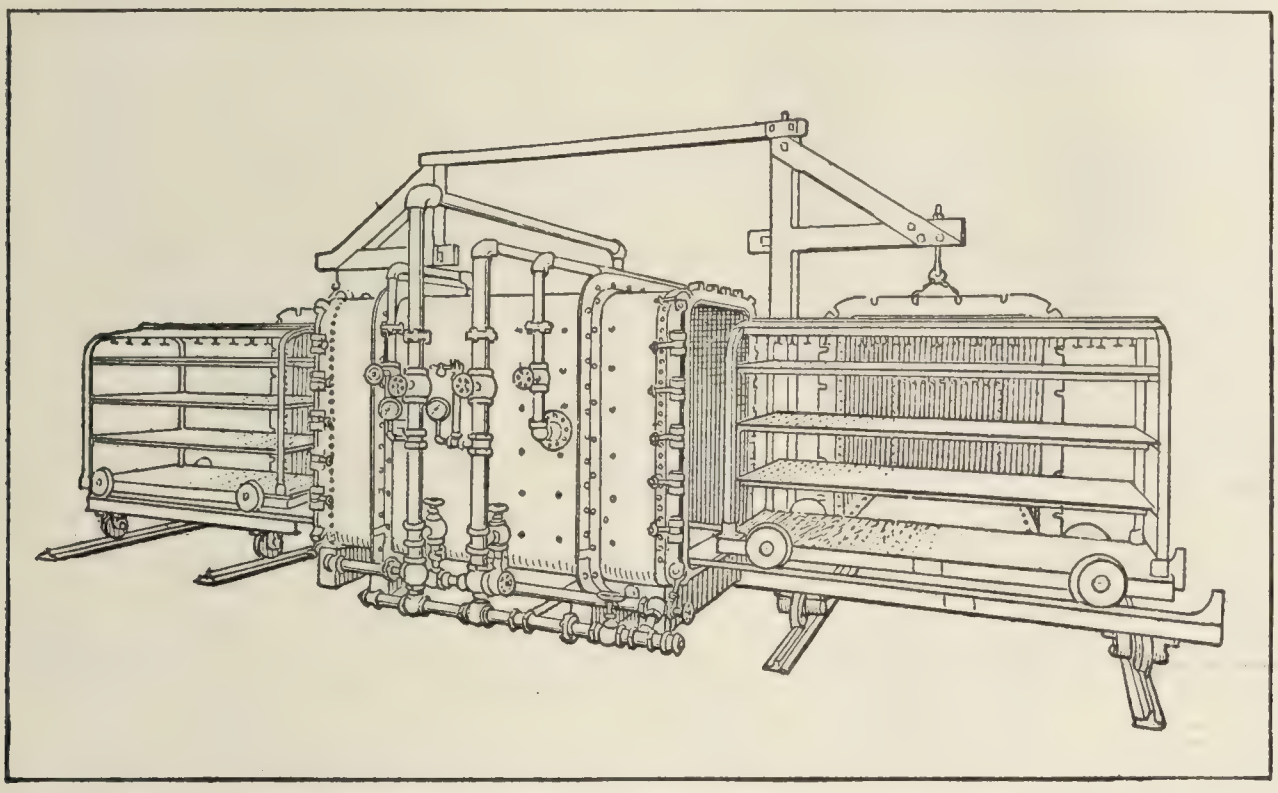


FIG. 357.—Kinyoun-Francis Steam Disinfecting Chamber.

other, thus securing complete isolation of the infected and disinfected articles. The cars, upon being unloaded, are returned to the working end of the chamber by means of transfer tables.

The working of such a sterilizing apparatus may be described as follows: The steam is generated in the boiler at high pressure, and by means of a reducing-valve is led to the chamber at the reduced pressure desired and allowed to circulate in the jacket. When the jacket is properly heated, the infected goods are loaded upon the car; it is then pushed into the chamber, the door closed and made steam-tight by fastening the bolts with a quick-action ratchet wrench, which draws the door tightly against the rubber gasket in the door frame. In a few minutes the temperature in the chamber will rise, and the vacuum apparatus is started until the gauge indicates about 15 inches vacuum. When the thermometer indicates the temperature of the incoming steam, if 10 pounds is used, say, 115° C., the pipes into the inner chamber are opened slightly at first, giving whatever direction of circulation is desired, and when the pressure has risen, the steam-pipes are closed and the vacuum pump brought into action until the vacuum gauge shows 7 inches. The vacuum pump is then shut off and the steam pipes are opened; the steam being allowed to circulate through the chamber at 3 to 5 pounds pressure and this circulation being maintained for the period of the exposure, when the by-pass valve is

opened wide to exhaust the steam. It can then be closed, and the air pump once more started to eliminate the dampness; then the door on the opposite end is opened and the car removed and unloaded.

The steam chamber and disinfecting plant should be located in an outbuilding, well provided with doors and windows and divided by a tight partition. The apparatus itself should be so placed that its operation should be easy, while there should be no risk of a re-infection of sterilized articles through contact with non-disinfected material in removal from the steam chamber after completion of the operation. From this danger such types of apparatus as are furnished with only one door are not free; to render such secondary contamination impossible, not only should the apparatus have two doors for entrance and removal respectively, but the room in which the infected articles are received should have no communication except through the open air with the room in which the sterilized articles are removed from the disinfecting chamber. It is scarcely

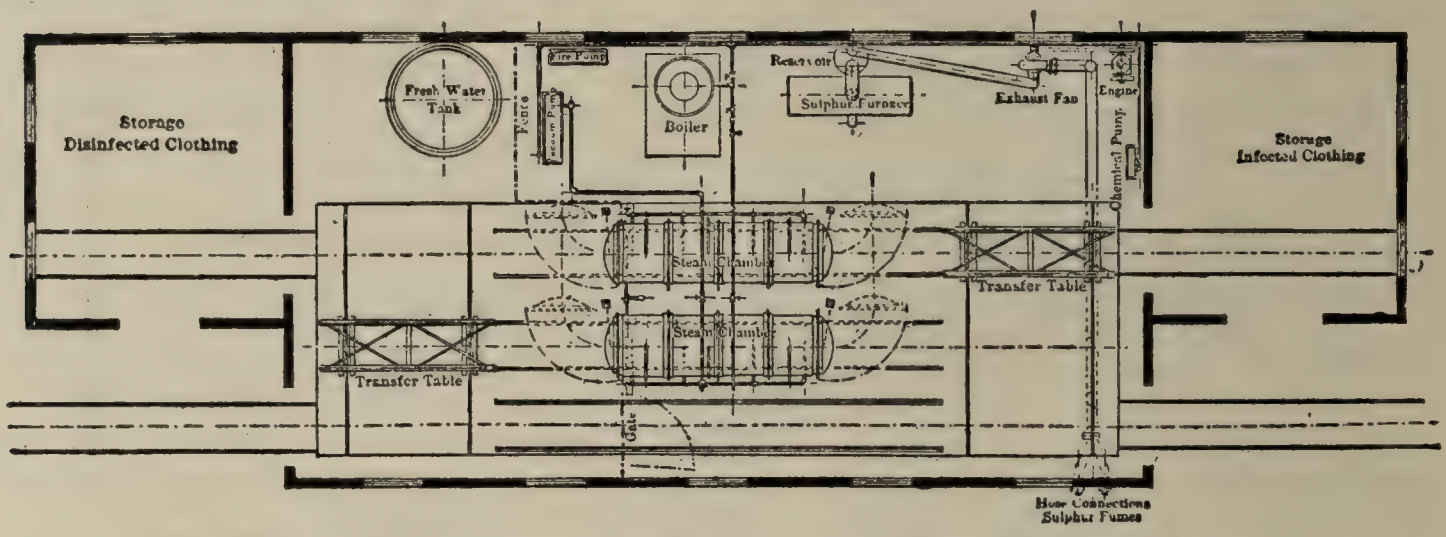


FIG. 358.—Ground-Plan Arrangement for Quarantine or Large Disinfecting Station.

necessary to say that the two doors of the steam-chamber should never be opened simultaneously. There should, of course, be two sets of attendants to handle the soiled and disinfected articles respectively.

A special movable apparatus for disinfection by steam under pressure might, with advantage, be supplied to each military department or to each army corps, as is the case in several European armies. This disinfector, while nominally attached to some large field hospital or military post, could be temporarily placed at the disposal of such organization as might require its services and would undoubtedly serve an excellent purpose, particularly in relation to troops in the field or during time of epidemic. The Kinyoun-Francis wheeled disinfecting apparatus was devised as a result of the problems presented in various epidemics of yellow fever in our southern cities. The apparatus consists of a beam frame mounted upon running gear, carrying the chamber, pump, coal and water tank and the locker-box seat. The chamber is composed of double steel shells, with a door at one end, handled by a crane attached to the chamber itself, and has a removable track, with a stand adjustable for the irregularities of the roadway, with a galvanized car of sufficient size to take single or double mattresses. The piping is so arranged as to give thorough control of the steam circulation, and has a reducing-valve, thermometer, vacuum and pressure-gauge and safety-valve. The boiler and pump are easy of access for working and are arranged compactly. In its method of operation the

portable steam-disinfecting apparatus closely resembles that of the fixed disinfecting plant, made by the same company, as just described.

Plants for disinfection by steam under pressure have the disadvantage of implying a considerable original outlay, as well as of requiring the services of a specially instructed mechanic for their manipulation. They furnish, however, the best method of accomplishing the disinfection of clothing, bedding and similar articles, and when viewed from the standpoint of the sanitarian, their increased cost and expense of maintenance are scarcely worthy of consideration where large hospitals, camps or posts are concerned. It is probable, also, that attendants of sufficient ability to take charge of such disinfecting plants would readily be found among the enlisted strength of the army and so diminish the expense of operation.

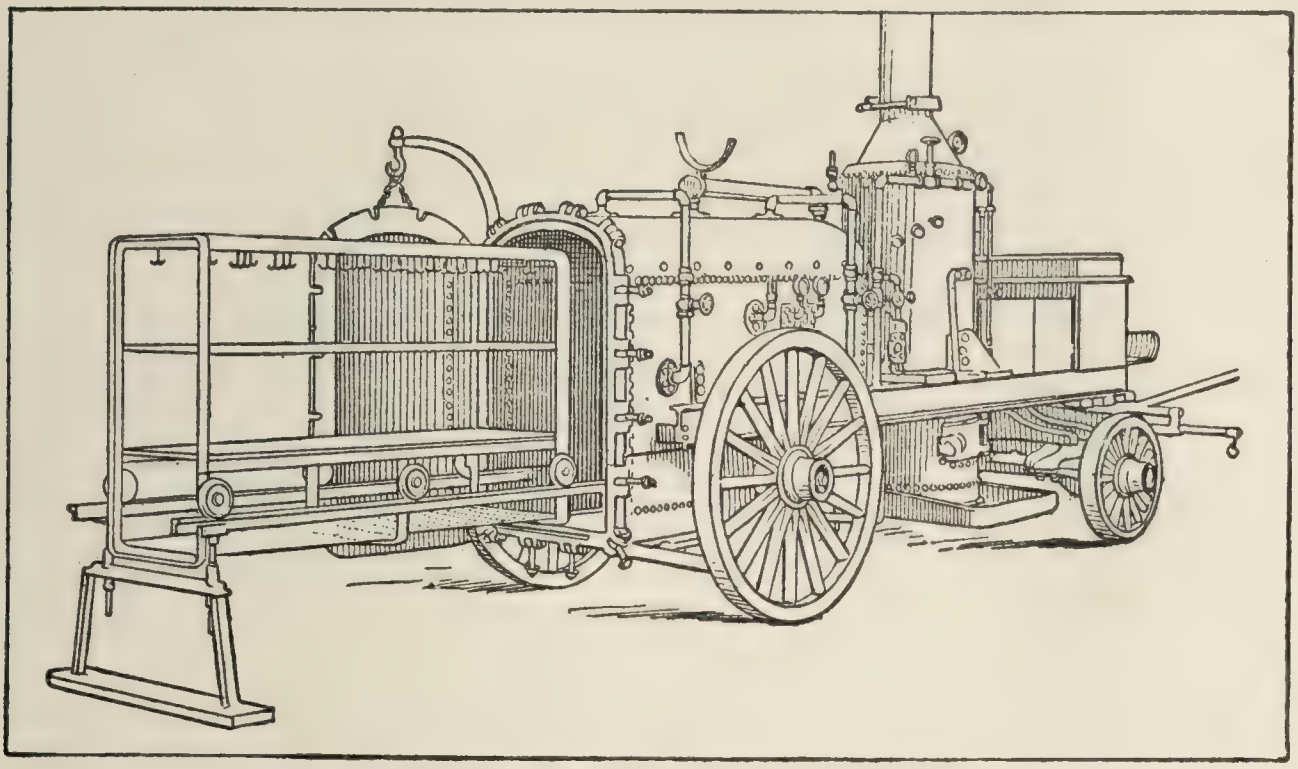


FIG. 359.—Kinyoun-Francis Steam Disinfecting Wagon.

CHEMICAL DISINFECTANTS.

The chemical substances used for purposes of disinfection are, for all practical purposes, limited to such as can be employed either in gaseous state or in aqueous solution; since when existing in dry solid form they can scarcely be brought into that intimate relation with all portions of an object which is required for its disinfection.

The essentials of a useful and trustworthy chemical disinfectant, as enumerated by Abbott, are: It must be a germicide—having the property of destroying bacteria and their spores. It should be so constituted that its germicidal properties are not destroyed by the extraneous matters in which the infective organisms that are to be killed are located. With ordinary care, it should not be directly poisonous to those who use it. It should, if possible, be without disagreeable odor, should be cheap in price, easy to manipulate, and for particular purposes should not cause permanent stains or be destructive to the skin, fabrics or other articles to which it is to be applied.

In many cases it is not possible to explain the manner in which disin-

fection is accomplished by chemical agents, any more than to say that the microbes are poisoned by the disinfectant; though in particular instances this is accomplished by a union between the disinfectant and the protoplasm of the bacteria; in others there seems to be a coagulation of the albuminoid constituents of the bacteria, while in others disinfection is accomplished through the disintegrating influence that the disinfectant has upon the bacteria.

While a large number of chemical substances are known to possess germicidal properties in greater or less degree, and hence may be variously employed in civil life for purposes of disinfection, the scope of this volume will necessarily preclude the discussion of such as are not officially issued for use in the military establishment of the United States.

Bichloride of Mercury.—$HgCl_2$. Bichloride of mercury, known also as mercuric chloride or corrosive sublimate, is soluble in 3 parts, by weight, of boiling water or in 16 parts of cold water. It is also readily soluble in alcohol. An aqueous solution of ammonium chloride will take up corrosive sublimate more readily than will water alone, a soluble double chloride (sal alembroth) being formed. This solution with ammonium chloride is very efficacious in the extermination of insect vermin, and is much employed for that purpose.

In its activity as a germicide, corrosive sublimate undoubtedly stands at the head of all chemical substances; a solution of 1–1000 strength promptly destroying bacteria together with their spores, a proportion of 1–10,000 being slightly germicidal and even a strength of 1–40,000 markedly restraining the development of micro-organisms. Its field of applicability is somewhat limited, however, by the fact that it rapidly attacks and corrodes metals, and that it unites with albumen in the formation of an insoluble albuminate possessed of practically no germicidal value. Modification of the first property being impracticable, all metallic objects should be promptly removed from its possible sphere of influence. Coagulation of albumen, however, may be largely prevented by the addition of a small proportion of acetic or tartaric acid to the sublimate solution. Wherever contact with albuminous material is liable to occur, the precaution of adding one of the above organic acids must be carefully observed, since, in the use of all chemical disinfectants which precipitate albumen, it must be understood that a part, or even the whole, of the active agent may be neutralized by contact with the albuminous material with which pathogenic bacteria are usually associated; while, at the same time, through the envelopment of these bacteria in an insoluble covering, a mechanical protection against their destruction is created.

Upon long standing, and particularly upon prolonged exposure to air and sunlight, corrosive sublimate in solution has a tendency to undergo reduction to mercurous chloride or calomel—a substance of no practical efficiency for purposes of disinfection. It is therefore advisable to add to its solution about 0.2 per cent. of hydrochloric acid; thus not only increasing the stability of the solution, but also increasing its destructive properties toward such micro-organisms as are unfavorably affected by an acid medium. According to Vignon, ordinary water ultimately causes the decomposition of the bichloride of mercury through the mineral and organic matter which it contains; hence such solutions should be freshly prepared and

rapidly utilized. In the presence of considerable amounts of calcium and magnesium salts this reduction is rapid and may even be complete, entirely destroying the value of the solution as a disinfectant. The use of hard waters in connection with mercuric chloride should, therefore, be carefully avoided, even though a previous boiling may remove a certain portion of the salts from the water it is desired to utilize. Distilled water should be employed for solutions wherever practicable, but in its absence rain-water will give satisfactory results. In the lack of water suitable for use with the mercury salt, reliance should be placed upon other disinfectants rather than in the employment of solutions of this substance which are necessarily of unknown strength and hence of doubtful efficiency.

Corrosive sublimate solution is extremely poisonous and at the same time possesses neither characteristic appearance nor odor; hence it is always well, in diminishing the dangers of its use, to add a sufficient amount of permanganate of potash or methylene blue to impart a noticeable coloration to the solution.

Mercuric chloride is rapidly removed from its solution by clothing. According to Kubla, a small piece of cloth soaked in 250 c.c. of a 1–1000 solution deprived the latter of its mercury in a few minutes. Similar results have been obtained by Sclavo and Mannelli, who found also that textures of animal nature removed corrosive sublimate from its solution much more readily and completely than cloths of vegetable origin. It is therefore advisable, in the disinfection of clothing by bichloride of mercury, to employ solutions of considerable strength; and, where articles are successively being treated by this agent, the renewal of the solution should be frequently practised.

For all the purposes of disinfection to which it can be applied, the acid solution of bichloride of mercury, having a strength of 1–1000, must be regarded as standard.

Carbolic Acid.—C_6H_5OH. Carbolic acid or phenol is manufactured from that part of the heavy oil of coal tar which boils between 150° C. and 200° C. It is somewhat heavier than water, and crystallizes in long needles, having a solubility in cold water of about 6.5 per cent.—or about three times that of "Tricresol." It becomes pink or brown on long standing, from the presence of some impurity.

For many years well known and widely employed as a germicide, carbolic acid has of late been largely displaced for purposes of disinfection by various other chemical substances of equal if not greater germicidal powers, and possessing in less degree the several properties which render the use of carbolic acid always unpleasant, somewhat dangerous and slightly uncertain.

The disinfectant properties of carbolic acid are so well recognized at the present day that any discussion thereon would seem to be superfluous. It is an active germicide; less so than was at one time supposed, but still sufficiently potent to satisfy the requirements of actual practice. A great disadvantage to its use in large quantities is the strong, disagreeable and lasting odor which accompanies its application.

For purposes of disinfection, carbolic acid is used in solutions of three to five per cent. strength by weight, care being taken to secure its solution by agitation and by the use of warm water. When employed in such a

strength, it has a wide range of applicability and gives generally satisfactory results in the disinfection of excreta, articles of clothing, objects of wood, leather or metal and for the disinfection of the walls and floors of habitations. A practical disadvantage in its use is its comparatively high price, even when the crude acid is employed, as compared with that of some other germicidal substances. In order to obtain its germicidal action, its solution must be thoroughly mixed with the matters to be disinfected so that it comes in intimate contact with them.

Crude carbolic acid and concentrated sulphuric acid, when mixed in equal parts, form a compound readily soluble in water and possessing germicidal properties superior to those of pure carbolic acid alone; the employment of the crude acid for this purpose is preferable to that of the refined substance. Obviously the uses to which this compound can be put are more restricted than those of carbolic acid alone.

Tricresol.—The name "Tricresol" is a trade designation, applied for commercial purposes to a mixture of ortho-, meta- and paracresol. This cresol group forms the next higher homologue to phenol; one atom of hydrogen in the latter being replaced by the methyl radical CH_3. The group is metameric with benzyl alcohol. Ortho- and paracresol are crystalline bodies having a low melting-point, while metacresol is a thick, colorless fluid. "Tricresol" is manufactured from coal tar, and is a white liquid having a specific gravity of about 1.045, possessing a strong pungent odor and a solubility in cold water of about 2.55 per cent.

According to Reed, a one per cent. solution of "Tricresol" will infallibly destroy the pus-producing micro-organisms in half a minute; a proportion of 1–800 being sufficient to restrain development. The presence of albuminous matter in fluids to be disinfected does not interfere to any serious extent with its prompt and certain germicidal action; an exposure of one and one-half to two minutes to a strength of one per cent. sufficing for sterilization. A proportion of one per cent. appears to be adequate for all purposes, and in comparing carbolic acid and "Tricresol" it would appear that the latter, bulk for bulk, is about three times as powerful a disinfectant. It should not be forgotten that, in equal quantity, "Tricresol" possesses toxic properties as great as those of carbolic acid.

Lime.—CaO. Lime, quicklime and calcium oxide are synonymous terms. The substance occurs in whitish, amorphous masses; odorless, alkaline and caustic. It is produced by heating the carbonate of calcium and so reducing it to the oxide. Calcium oxide combines with about one-third its weight of water, with the evolution of considerable heat and an increase of bulk, in the production of powdered calcium hydrate or water-slaked lime. If a larger quantity of water be employed, the so-called "milk of lime" results, a solution temporarily holding an indefinite excess in suspension. When treated with 700 parts of cold water the hydrate is wholly dissolved to a clear solution, which is "lime-water." If exposed to the atmosphere, quicklime is rapidly acted upon by the carbonic acid and moisture of the air, and, when completely air-slaked, is decomposed into a mixture usually containing something over fifty per cent. of calcium carbonate and something less than fifty per cent. of calcium hydrate, according to the amount of moisture present in the atmosphere. As the former substance is of no utility for purposes of disinfection, the necessity for

insistence upon the employment of freshly-burned lime, not more than four or five days from the kiln, water-slaked, becomes evident. If freshly burned lime cannot for any reason be supplied at the point where disinfection is required, its shipment should be made in small lots, well packed to exclude air and moisture.

Since 1890 the use of lime as a disinfectant has been officially sanctioned in the armies of France, Germany and Great Britain. The value of this substance as a disinfectant depends upon its caustic alkalinity. It may be used in a dry state as well as after slaking; but under the former condition a much greater quantity is required and the results are not usually as satisfactory. Being extremely cheap and at the same time not a powerful germicide, it should always be added to the infectious matter in large excess or until the mixture is strongly alkaline. Milk of lime, as officially prescribed for use in the army of the United States, is to be prepared by the addition of one part, by weight, of the freshly hydrated lime to eight parts of water. In its application to quantities of fæcal matter the milk of lime is to be employed in the proportion of five per cent. by bulk; with a daily addition equal to ten per cent., by bulk, of the estimated increment of fæces. According to this method of employment, to each 95 parts of fæces there is added .62 part of water-slaked lime—or 1 part in 153. This would seem to be an extremely small proportion for a substance of no very powerful germicidal powers, particularly in the absence of thorough mixing with the infectious material or with the deterioration of the lime through atmospheric influences, which is so liable to occur. In view of the extreme cheapness of quick-lime, and to avoid any possible failure in the attainment of disinfection, it will do no harm to err upon the side of safety and considerably to increase the strength of the milk of lime as prescribed above. Most modern authorities recommend that milk of lime be made by adding one part of lime to four parts of water. The quantity of lime used should, of course, always bear a definite ratio to the bulk of the infectious material to be disinfected. A perfunctory sprinkling of infectious matter with weak milk of lime, as is so often done, is a procedure worse than useless—since it accomplishes little or nothing in the way of disinfection and at the same time engenders a feeling of false security. Quicklime has but a slight effect in the destruction of odors and requires some little time for the accomplishment of disinfection, often several hours. Where milk of lime is used for the disinfection of fæces, it should not be thrown into a water-closet without dilution and the flushing of the trap, since otherwise the thick mass may accumulate and stop the pipes.

Whitewash is a thickened mixture of quicklime and water to which, to increase its cohesive powers, sizing is sometimes added. Wherever lime is employed for purposes of disinfection, it should be freshly burned—and its use in whitewash is no exception to this rule. Too often a whitewash is composed chiefly of calcium carbonate, which possesses no germicidal properties whatever. Giaxa found that ordinary whitewashing with hydrated lime destroyed all micro-organisms except the spores of anthrax and the bacillus of tuberculosis. Lapasset obtained excellent results, in disinfection by whitewashing, by mixing five parts of water with two parts of quicklime and then adding an equal quantity of boiling water contain-

ing five per cent. of sizing. To increase the germicidal action of ordinary whitewash, a small proportion of chlorinated lime is sometimes added in the preparation of the former. Prior to the application of whitewash to a surface, all loosely adherent dirt or lime should be removed by scraping; the actual removal of a large proportion of the bacterial life being preferable to its burial under a coating of whitewash. This scraping, however, should be carefully done and every precaution taken not to promote, by this very action, the dissemination of the micro-organisms throughout the habitation.

Chlorinated Lime.—CaCl.OCl. Chlorinated lime or bleaching powder, popularly miscalled "chloride of lime," is a white powder of peculiar chemical composition and somewhat unstable nature, resulting from the exposure of moist calcium hydroxide (water-slaked lime) to nascent chlorine gas—about 56 per cent., by weight, of the latter substance being absorbed.

Chlorinated lime is an excellent desiccant and a powerful deodorant, vigorously attacking and decomposing hydrogen sulphide and volatile ammoniacal compounds. As a disinfectant, its valuable properties have been established by the researches of Sternberg and others. Its efficiency as a germicide depends upon its available chlorine, of which, as prescribed by the United States Pharmacopœia, at least 25 per cent., by weight, must be present.

It undergoes decomposition on exposure to the air, through liberation of its chlorine by the carbon dioxide of the atmosphere, and hence should be stored in closed vessels in a cool and dry place. In its slow decomposition, chlorinated lime is liable to lose a small proportion of its oxygen in the production of true chloride of lime ($CaCl_2$) which, by its affinity for moisture, renders the bleaching powder deliquescent. Chlorine, when slowly evolved from bleaching powder, unites with the carbon dioxide of the atmosphere in the formation of hypochlorous acid—an even more powerful disinfectant than chlorine itself.

As a disinfectant, chlorinated lime may be directly applied in the dry state. Equally as good results, however, are obtained by its use in strong watery solution and the method is much more economical. The addition of water to chlorinated lime is generally admitted to yield a mixture of calcium hypochlorite ($CaClO_2$), calcium chloride ($CaCl_2$) and some calcium hydrate ($CaOH_2$); of which latter substance a large quantity remains as an undissolved residue. The efficiency of this solution as a disinfectant depends chiefly upon the presence of the calcium hypochlorite, which is readily decomposed, even by carbonic acid, with the liberation of hypochlorous acid. This acid itself, when exposed to light, is decomposed into chloric acid and free chlorine. For use in the disinfection of rooms, Chamberland and Fernbach advise the preparation of a solution of chlorinated lime made by covering one part of the bleaching powder with an equal amount of water. After standing an hour the mixture is filtered and a greenish-yellow liquid obtained; one part of this solution being added to ten times its volume of water for application to the surface to be disinfected. As a result of their investigations, it is claimed that this weak solution is fully as efficacious for purposes of disinfection as a stronger one. If possible the solution should be applied hot, and the room which is being disinfected should also have its temperature elevated. A solution of good

chlorinated lime in water in the strength of one-half to one per cent. by weight has been shown to disinfect typhoid and cholera stools in ten minutes, while a one per cent. solution will destroy the anthrax bacillus in two hours. Thorough mixing of the chlorinated lime solution with the material to be disinfected is essential. Its use is without danger to the operator and it leaves no poisonous residuum in the room disinfected. In the United States army, a four per cent. strength of chlorinated lime in solution is officially prescribed for use in the disinfection of the excreta of the sick; it being specifically stated that the chlorinated lime so used should be of good quality and not have undergone deterioration. The disagreeable odor resulting from the use of chlorinated lime in rooms may be removed by hanging about cloths soaked in strong soda solution after disinfection is complete.

The Hypochlorites.—The employment, for the purpose of disinfection, of calcium hypochlorite — $CaClO_2$—has already been noticed in connection with the use of chlorinated lime in watery solution. Labarraque's solution, or a solution of sodium hypochlorite—NaClO—appears to be somewhat less actively energetic than the solution of calcium hypochlorite, and as it is also more costly the employment of the latter is preferable. Its germicidal properties of course depend upon the amount of chlorine available on the decomposition of the sodium salt. Labarraque's solution may contain as much as six per cent., by weight, of chlorine, and the standard of the United States Pharmacopœia requires that it shall contain no less than 2.6 per cent. For purposes of disinfection one part of the solution is usually added to four parts of water—but in practice sodium hypochlorite is employed almost exclusively for the disinfection of the person.

In this connection the disinfectant solution prepared from sea-water may be noted; the chlorides normally present being converted into the hypochlorites by electrolysis. A plant for the production of this disinfectant solution, under the trade name of "Electrozone," was put in practical operation in the municipal sanitation in Havana while under control of the United States military authorities. It was claimed that the sea-water so treated had an average chlorine strength of 0.16 per cent. The solution was distributed in wagons for use in disinfecting sewers, street sprinkling and household disinfection. It was shown by Reed, however, that the chlorine strength claimed was not obtained in practice, and in observations covering a period of ten days the available chlorine in the electrolyzed sea-water varied from a maximum of 0.142 per cent. to 0.021 per cent. A chlorine strength of less than 0.15 per cent. cannot be relied upon for prompt disinfection, and a solution containing a minimum of 0.25 per cent. is desirable. Reed therefore concluded that the "Electrozone" as used in Havana did not possess sufficient strength for efficient and reliable disinfection. His experiments showed that a solution of sodium hypochlorite of equal chlorine percentage is just as effective in germicidal action as electrozone, and the same is true of chlorinated lime to which enough of hydrochloric acid has been added to free the whole of the chlorine. Comparing the relative cost of production, Reed found that ordinary chlorinated lime solution of a definite and constant disinfectant value could be supplied much cheaper than "Electrozone," which had no particular standard of strength.

Ferrous Sulphate.—$FeSO_4$. Ferrous sulphate, also called sulphate of iron or copperas, occurs in green, efflorescent crystals, readily soluble in twice their weight of cold water. On account of its inferior germicidal powers as well as its property of staining fabrics, the employment of sulphate of iron is practically limited to its application to fæcal matter, for which purposes its marked capacity for the destruction of bad odors renders it particularly suitable. It is extremely cheap, easy of application and, unlike other substances, does not impair the fertilizing value of the matter to which it may be applied. The properties of ferrous sulphate which render it useful for purposes of disinfection depend upon its tendency to appropriate oxygen and so become converted into the ferric sulphate. These qualities, however, must be considered as antiseptic rather than disinfectant, since, according to Laveran, the addition of even five or six per cent. of the salt to fæcal matter is unable uniformly to effect the sterilization of the latter.

Sulphate of iron is used only in solution; the amount of the iron salt to be daily employed depending upon the estimated increment of the fresh fæcal matter rather than upon any particular strength of the solution. Should the contents of the latrine be semi-fluid, the solution of sulphate of iron may with advantage be made up with but a small proportion of water, since for efficiency a high proportion of ferrous sulphate should be brought into direct contact with the excreta. In practice, a proportion of five parts of the iron salt in each hundred of the total contents of the latrine vault should be considered as essential to efficiency. In the French army, ferrous sulphate is much used for the disinfection of latrines in a ten per cent. solution. It is officially laid down that at least 250 c.c. of such a solution should be used per day for each person using the latrine.

Chemical Disinfection by the Use of Sprays.—Various types of apparatus for the projection of disinfectant solutions, in a finely divided spray, have been largely employed in the disinfection of buildings; more so in Europe than in this country. All are much alike in structural detail and in results obtained. Late models are lined with ebonite or hard rubber, to permit the use of corrosive sublimate solutions without inducing the deterioration of the apparatus, and are sometimes mounted on wheels so as to allow of their more ready transfer from place to place. The nozzle of the apparatus is not of the ordinary "rose" form, but is constructed on the same principle as in the small hand atomizer; the fluid being aspirated into and projected by a strong current of compressed air. For the use of these sprays two men are required, one to direct the jet of spray and the other to work the pump. The spray apparatus delivers the disinfectant solution with considerable force and in the form of a fine, almost invisible mist. The walls are not sluiced down, but the extremely minute globules are intended to remain adherent to the wall without coalescing into large drops. Even with the fine division of the disinfectant spray it is, however, difficult to obtain a general microscopical moistening, and to secure the best results the nozzle must be held at the distance of only a few inches, not more than four or five, from the surface to be disinfected.

To determine the completeness with which a surface is moistened at any distance, a simple and ready test consists in the projection of colored fluid from the spray apparatus against white paper, and the subsequent ex-

amination of the latter with the aid of the microscope. With the use of the spray a much smaller amount of disinfectant solution is naturally required than if the walls are washed down, although the quantity varies largely according to the character of the surface treated. With the Geneste-Herscher apparatus a single quart of solution will moisten an oil-painted surface of sixty square yards; although for walls generally, most of which are porous and absorbent, an average of about two quarts for each three square yards will be required. It is not possible satisfactorily to spray hot solutions, since heated liquids are rapidly cooled by the act of projection itself. According to Laveran, the difference in temperature shown

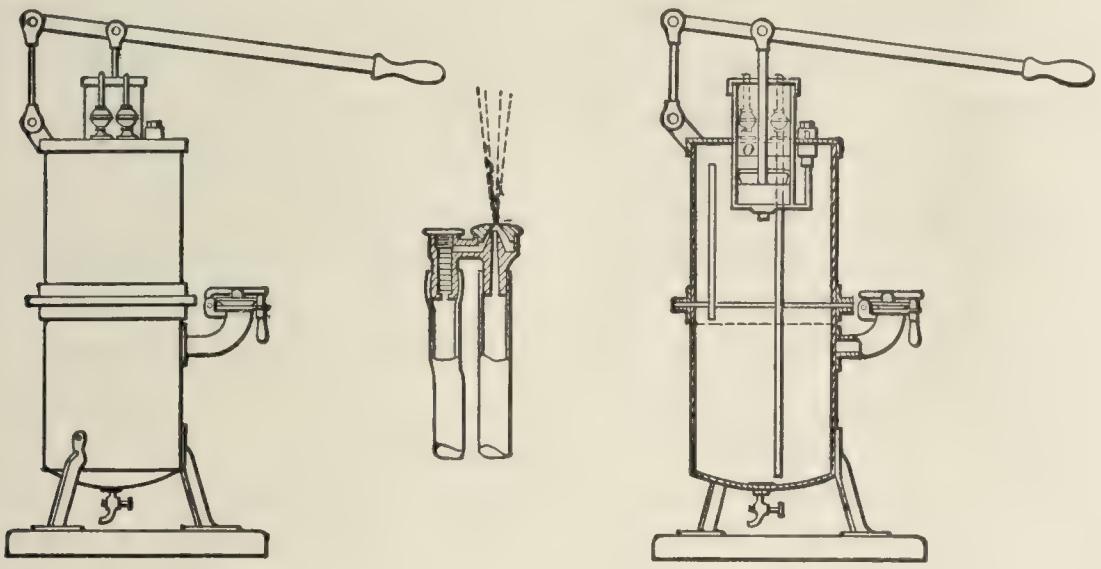


FIG. 360.—Apparatus for Disinfecting Walls by the Use of the Spray, as Used in the French Army.

by a thermometer sprayed at the nozzle of the apparatus and again at the distance of one meter was 31° C.; the thermometer in the last instance registering a temperature somewhat lower than that of the surrounding air.

The use of the spray apparatus for wall and ceiling disinfection is a great economy of labor. With a hand-brush and solution, a workman can disinfect about sixty square yards of surface per hour; while with an atomizer from ninety to two hundred square yards, according to the height, conformation and porosity of the wall, can be thoroughly sprayed in the same time. On plastered or calcimined walls most bacteria are rather resistant to the action of the disinfectant—much more so than on painted walls. On papered surfaces the results are frequently unsatisfactory.

After spraying with a solution of mercuric chloride of 1–1,000 strength, Esmarch noted a great diminution in the number of the germs present but rarely a complete sterilization, the spraying being continued until large drops of the solution collected on the wall. As a result of extensive experiment he concluded that the use of the spray was followed by too uncertain results to render its employment of practical utility and gave inferior results to the method of disinfection by rubbing down the walls with stale bread. The use of 1–1,000 bichloride solution as a spray gave Laveran no very gratifying results, and even in the strength of two and four parts per thou-

sand the results were not always positive; the bacillus of anthrax always proving resistant and other common pathogenic micro-organisms frequently being undestroyed. It is well to note, however, that Laveran removed the corrosive sublimate at once after spraying so as to avoid its inhibitory action in cultures subsequently made, and it can be readily understood that a more prolonged exposure *in situ* might have resulted in the actual destruction instead of the inhibition of the micro-organism. Opposed to the above are the favorable results obtained by Guttman and others in the use of the spray with strong acid corrosive sublimate solution; a solution containing three parts of bichloride and five parts of hydrochloric acid per thousand being recommended. As a whole, the results obtained with the spray apparatus appear to depend upon the distance at which the operation is carried out, the duration of the spraying, the nature of the material in which the microbes may be embedded, the amount of fluid projected and to a large extent upon the character of the wall. It appears to be amply demonstrated that with the use of a strong germicidal solution, sprayed from a short distance for a considerable period, reliable results may be anticipated.

For sluicing down the walls, in the absence of any special apparatus, the use of the ordinary cheap spray-pump, such as is used for spraying flowers or washing carriages, will answer all purposes, provided no solution destructive to the metal, such as bichloride of mercury, be employed. Such a pump is cheap, light and small and can be worked by one man.

Formaldehyde in watery solution is now much used in the form of a spray for the disinfection of small articles, it appearing to give more certainly positive results than follow the use of other germicidal solutions by atomization. In its employment, due care must always be taken to use an amply effective strength, erring on the side of safety if at all. To leave no doubt as to the thoroughness of the results obtained, it is safe to say that no solution containing less than 2.5 per cent. of formaldehyde gas should be employed. A strong solution of formaldehyde appears to exert no more of a deleterious effect upon the articles to be disinfected than do weaker solutions, and hence the only question concerns a possibly slightly increased financial outlay. Articles such as carpets, clothing or hangings may be satisfactorily disinfected by spraying with a solution containing ten per cent. of "formalin" (four per cent. of formaldehyde gas); care being taken to continue the operation for some minutes and to make sure that the spray has reached all portions of the surface or fabric. As a matter of fact, it is usually extremely difficult to remain in the room until the completion of the operation of spraying; the operator finding it necessary frequently to withdraw temporarily to the purer air outside. Stahl found that clothing and similar articles could be made germ-free by spraying with solutions containing one-half to two per cent. of formaldehyde gas, provided they were sprayed some little time—ten to twenty minutes—and that the application of a solution containing as little as one part of formaldehyde in twenty-five thousand was sufficiently powerful to prevent bacterial develop-

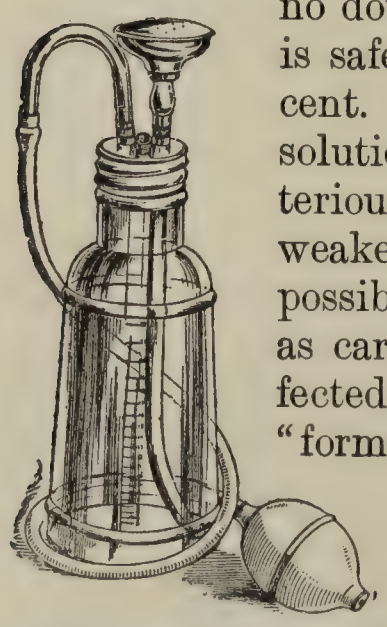


FIG. 361.—Formalin Spray Apparatus Used by the Chicago Board of Health.

ment. In employing formaldehyde solution as a spray, it is well to remember that it hardens the unbroken skin, rendering it rough, whitish and anæsthetic—while on abrasions it produces a burning, painful sensation and ultimately induces superficial necrosis. Blankets and bedding, if used too soon after spraying with such a solution and without sufficient airing, may induce bronchitis and considerable irritation of the conjunctivæ. The use of a spray of "formalin" (40 per cent. formaldehyde) for the disinfection of all the surfaces and articles in a closed space, as well as the surfaces actually moistened, is now habitually employed in room disinfection by the Chicago board of health; the procedure depending for its general efficiency upon the formaldehyde gas evolved. For every thousand cubic feet of space in the room is suspended, by one edge, an ordinary bed sheet (two by two and one-half yards) from a line stretched across the middle of the room. Properly sprinkled, this will carry without dripping five ounces of "formalin"—which is sufficient to disinfect one thousand cubic feet of space. As many sheets as may be necessary are used, hung at equal distances apart. The ordinary, rather coarse cotton sheet should be employed in order to secure rapid volatilization. Care should be taken that the spray is very fine and that the edges of the drops do not touch each other, for if the sheet is actually wet the solution evaporates slowly and produces the solid paraform, instead of passing directly into the air as formaldehyde gas. The sprinkler used by the Chicago board of health is perforated by eight minute holes one-fourth of an inch apart and about one millimeter in diameter. The container will hold twenty-two ounces of formalin, sufficient for four sheets or enough to secure the disinfection of four thousand cubic feet of space. The results obtained by this process are very satisfactory; and its simplicity, freedom from danger and lack of bulky or expensive apparatus render it especially adapted to the needs of the military service.

GASEOUS DISINFECTANTS.

The ideal disinfectant is a gas, prompt in its action and certain in its results, which, readily penetrating to all parts of a confined space, will permeate articles to be disinfected without deterioration of their qualities. Non-toxic to the higher forms of life, it should be capable of ready generation, easy manipulation and absolute control. It should be a good deodorant, and if its possess an odor itself it should be one capable of rapid dissipation.

A considerable number of gaseous substances have been at various times employed for purposes of disinfection, but, with the exception of chlorine, sulphur dioxide and formaldehyde their use in the military establishment, as in civil life, has been definitely abandoned. Some of these once vaunted disinfectants, as, for instance, the vapor of boiling vinegar, have been demonstrated to possess no germicidal value, while others, as bromine, iodine and nitrogen dioxide, have been discarded by reason of their poisonous and destructive properties and the difficulties attending their manipulation. These latter substances possessing, at the present time, a purely theoretical interest, any consideration of other than the three first named is unnecessary.

Chlorine.—Cl. This body, first used in 1774 for purposes of room

disinfection, is a greenish-yellow gas, possessed of characteristic and disagreeable odor, rapidly corroding metals and having an intensely irritant effect upon animal tissues. In its employment every precaution against its respiration should be taken, since if inhaled in even weak proportion it may produce spasm of the larynx, severe bronchitis and even death.

Chlorine in considerable volume may be generated by mixing 18 parts, by weight, of fine table salt with 15 parts of pulverized binoxide of manganese and adding a mixture containing 45 parts of commercial sulphuric acid and 21 parts of water. Evolution of the gas, at first rapid, becomes gradually slower but may be hastened by the action of gentle heat. It may also be prepared by adding 4 parts, by weight, of strong hydrochloric acid to one part of manganese dioxide. Chlorine is readily produced by the action of any acid, no matter how weak, upon chlorinated lime or bleaching powder. While chlorinated lime theoretically contains about 56 per cent. of chlorine, that proportion may not actually be obtained on decomposition, owing to greater or less deterioration and loss through atmospheric influences. One pound of fresh chlorinated lime, however, on being treated with sufficient acid for its complete decomposition, may be expected to evolve about 2.8 cubic feet of chlorine gas.

Chlorine is an efficient deodorant through its great affinity for hydrogen, readily decomposing hydrogen sulphide, ammonia and volatile aromatic bodies; the resulting hydrochloric acid further neutralizing a certain amount of ammonia. Chlorine is also able to decompose water, particularly in the presence of sunlight, by uniting with the hydrogen and liberating the oxygen; which latter substance, in its turn, attacks and decomposes such organic matter as may be within reach of its action. Chlorine does not readily combine with hydrogen in the dark, but when exposed to light these elements unite with a rapidity proportionate to the intensity of the actinic rays in the light employed. Exposed to ordinary diffuse light, the chemical combination is slow—a fact of practical importance in the consideration of the disinfection of such dark places as sewers, cesspools or privy vaults.

At the present time, when employed at all, free chlorine is used rather as a deodorant than a disinfectant. Its germicidal action appears to be uncertain and to depend in large degree upon the amount of moisture present in the atmosphere. Through its high specific gravity, 2.47, chlorine has a constant tendency to seek the lowest level—and hence anything like its equal diffusion, in the disinfection of a large room, can scarcely be obtained. The gas has little powers of penetration, and its use, if any, must be practically confined to surface disinfection. In order effectively to utilize chlorine for room disinfection, the proportion of the gas in the atmosphere must be carried to a degree which will result in the extensive bleaching of colored fabrics—a serious hindrance to its practical employment in the military service.

Sternberg found that an exposure of six hours to a constant strength of one-half of one per cent. of chlorine was necessary to destroy the potency of vaccine virus. According to Notter and Firth, a proportion of 0.5 per cent. is fatal to all micro-organisms in five to eight hours, while 0.3 per cent. destroys bacterial life in the presence of moisture. A rapid and considerable diminution in the percentage of the gas originally present must

always be anticipated through unavoidable loss by diffusion; and in its application to room disinfection a strength of one per cent. of chlorine must be considered as the minimum. For the proper disinfection of a tight chamber of a thousand cubic feet capacity, the decomposition of about four pounds of good bleaching powder by about one pound of strong sulphuric acid would therefore be required. For practical purposes of disinfection, free chlorine is much inferior to sulphur dioxide; since it is more difficult to control, more dangerous to manipulate and more destructive in its effects.

Sulphur Dioxide. — SO_2. Through the ease with which it can be generated, as well as its comparatively slight cost, sulphur dioxide is a favorite agent for purposes of disinfection. Possessing powerful reducing properties, its action is directly opposite to that of chlorine; it having an affinity for oxygen while chlorine eagerly unites with hydrogen. Sulphur dioxide gas is very irritant to the mucous membranes, and, while it has no such marked toxic action as chlorine, due caution should always be observed in its employment. It condenses to a clear liquid at 18° C. (the temperature of a mixture of ice and salt) even at the ordinary pressure of the atmosphere. It is a heavy gas, having a specific gravity of 2.21, and this property, by preventing its ready diffusion in the atmosphere, operates to some extent against its efficiency as a disinfectant.

As ordinarily carried out in practice, sulphur dioxide, for purposes of disinfection, is obtained by combustion of the element sulphur in the atmosphere. The sulphur to be burned should be carefully calculated in amount according to the size of the room to be disinfected, and should be reduced to small fragments to favor its more ready and complete combustion. For a similar reason the necessary amount of sulphur should be divided into several portions located in different parts of the room, rather than placed in large quantity in a single utensil. From the high specific gravity of the gas, the sulphur to be burned should be elevated some little distance above the floor rather than placed upon it. For its combustion, large iron pots serve an excellent purpose and are always available. These pots, containing the necessary amount of sulphur, should be placed on bricks in a tub of water in order to lessen the dangers of accidental conflagration. The contents may be ignited by live coals or shavings—but better by the free use of alcohol. The operator should at once retire to avoid the irritant fumes which are rapidly generated, the door is tightly closed and all crevices are quickly sealed. For safety as well as rapidity, it is well to employ two men in the work. The room should remain closed for twenty-four to thirty-six hours, after which the windows should be thrown open, from the outside if possible, and the apartment thoroughly aired for some hours. Sulphur dioxide is very soluble in water, the latter taking up nearly forty-five times its bulk of gas, and hence it more readily attacks micro-organisms in a moistened and less resistant state. To assist its action the atmosphere should be impregnated with watery vapor; and this may be produced, without additional diminution of the available oxygen in the room, by vaporization of the water surrounding the pot in which the sulphur was placed, through the heat generated by the combustion of the sulphur itself.

About one-half pound of water should be vaporized for each pound of

sulphur burned, to allow for unavoidable defects or losses; although theoretically only one-fifth pound of water should be volatilized, for each pound of sulphur burned, in the conversion into sulphurous acid of the sulphur dioxide produced. This matter of a sufficiency of water vapor is essential to the success of the operation of disinfection; Geddings having found that an exposure of forty-eight hours to a 9.2 per cent. strength of dry sulphur dioxide was unable to destroy various pathogenic bacteria, while micro-organisms under the same conditions were uniformly killed by as low a strength as 1.6 per cent. with an exposure of eighteen hours, when an abundance of watery vapor was provided. A previous elevation of the temperature of the room, particularly in cold weather, will greatly assist the germicidal action of the sulphur dixoide.

Prior to a general disinfection by sulphur dioxide, such metallic objects as are readily attacked by this body should be removed from its intended sphere of influence. It is of the greatest importance hermetically to seal all openings from the outside, pasting over with paper all cracks or apertures in walls, windows and doors and stuffing chimneys with newspapers; since in many instances where this precaution has not been taken the gas so rapidly escapes and its proportion diminishes to such a degree as to destroy its germicidal efficiency. Thus Wolffhügel found that the air of a chamber which at the beginning contained 18 per cent. of sulphur dioxide, by volume, contained only about 4 per cent. at the end of an hour and but 1.8 per cent. at the end of three hours.

The experiments of Sternberg on vaccine lymph would seem to show that, in order to be effectively germicidal, sulphur dioxide should be present in the atmosphere in at least the proportion of 1.4 per cent. According to Wernich, if the proportion of sulphurous acid reaches 4 per cent. it becomes an efficient germicide; while Marty placed the minimum at 4.7 per cent. According to Thoinet, an exposure of twenty-four hours to a strength of 4 per cent. invariably destroyed the germs of tuberculosis, cholera, glanders, typhoid fever and diphtheria, provided the chamber did not permit of the escape of the gas; but the micro-organism of anthrax was resistant under those conditions. Wolffhügel was able to destroy anthrax spores by exposure for twenty-four hours to a 4.5 per cent. strength, working under laboratory conditions implying an air-tight apartment and an atmosphere saturated with moisture; but he concluded that under the conditions found in actual practice sulphurous acid must always be considered as a somewhat uncertain disinfectant—an opinion shared by Cassedebat. In view of the many factors which may exert a powerful influence in impairing the germicidal powers of sulphurous acid, it is well to err upon the safe side, if at all, in determining the working minimum for all conditions. From this standpoint the requirement of a four per cent. strength, by volume, will not seem excessive.

One pound of sulphur, when completely burned in the atmosphere, evolves 11.2 cubic feet of sulphur dioxide. A four per cent. strength of sulphur dioxide, by volume, may be obtained by the complete combustion of not less than four pounds and two ounces of sulphur to each one thousand cubic feet of air space in an absolutely air-tight compartment, and this should be the amount of sulphur employed. A greater proportion of the gas, such as the six, or even ten per cent. strength commonly used in

ship disinfection by the Marine Hospital service, can be obtained only by means of a special furnace or by the employment of liquefied sulphur-dioxide gas.

A recent and eminently satisfactory method for the generation of sulphur dioxide for purposes of disinfection consists in its evolution from the liquid state, in which, as supplied in tins, siphons and carboys, it is a common article of commerce. In the use of the liquefied sulphur dioxide the danger of accidental fire is avoided, the substance is readily handled and a much greater amount of the gas can be thrown into the atmosphere in a short space of time; thus avoiding the constant escape of gas by diffusion through the long period of its production, as effected by the ordinary combustion of sulphur.

To offset the advantage of this method, however, it should be borne in mind, having reference to the atomic weights of sulphur and oxygen, that one pound of sulphur will produce two pounds of sulphur dioxide by its combustion. It is evident, therefore, reversing the proposition, that two pounds of liquefied sulphur dioxide must be used in lieu of each pound of sulphur required—the claims of the manufacturers to the contrary. The method of utilization of the liquefied gas is extremely simple. If the sub-

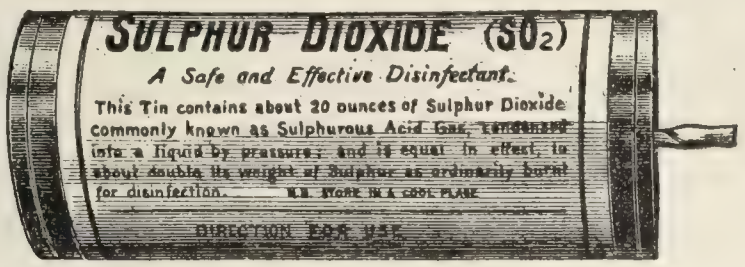


FIG. 362.—Commercial Tin of Liquefied Sulphur Dioxide.

stance is used in the small tins, it is only necessary to cut simultaneously the leaden pipes in the tops of the necessary number of cans and invert the latter in an ordinary wash-bowl or iron pot, when volatilization rapidly occurs. If the substance be contained in glass or metallic siphons, the room can first be sealed and then the necessary amount of liquid sulphur dioxide projected from the outside through a small pipe, passed through the keyhole or other small aperture, into a suitable receptacle. For this purpose, the internal pressure in the siphon is sufficient. The increased expense attached to the use of liquefied sulphur dioxide has been something of a drawback to its general employment—the disinfection per thousand cubic feet by its use costing eighty-five to ninety cents, where the solid sulphur necessary for the same space, together with the alcohol used in its ignition, would cost only about one-tenth of that amount. Its convenience, safety and especially the fact that by this method any proportion of the gas can quickly and readily be obtained in a given space, should, however, outweigh any minor questions of expense. It has recently been prescribed for use in the British army in lieu of roll sulphur.

Sulphur fumes of relatively weak strength possess but slight powers of penetration. In the proportion usually obtained by the ordinary method of the combustion of sulphur, too great reliance must not be placed upon simple fumigation with sulphur dioxide in the absence of other and accessory measures of disinfection. To be thoroughly efficacious, prolonged exposure to a considerable proportion of the gas, in the presence of moisture,

is required. The destructive properties of this substance as regards fabrics may often furnish a strong argument against its use.

Formaldehyde.—CH_2O. This is a colorless gas, extremely irritating to the mucous membranes and of a strong, pungent odor. It possesses the same specific gravity as air—a fact of great practical importance in regard to its distribution when used as a disinfectant for large spaces. It is somewhat unstable and is of neutral reaction; although toward alkalies it behaves something like an acid but does not form true salts. At common temperatures it is but slightly soluble in water; but by cooling and agitating, a solution containing forty per cent., by weight, can be made. Its solubility is increased if wood alcohol be added to the water—but in such cases the gas appears to combine with the alcohol and not form a simple solution. According to Trillat, if such an impure solution be heated, the methyl alcohol combines with a certain quantity of formaldehyde in the production of methylal, a body said to possess no germicidal properties whatever. Whenever the gas or its saturated solution is cooled to 20° C. it forms a solid by polymerization, called paraformaldehyde, through the union of two molecules—and the same body is formed by boiling down a solution of the gas in water. This polymeric product is a white, soapy substance, soluble in water and alcohol. When this latter substance is dried in vacuo, over sulphuric acid, a third body, trioxymethylene, is formed, consisting of three molecules of CH_2O. This is a white powder which gives off a strong odor of formaldehyde. Both these polymers are apparently restored to the simple gaseous molecule by heating in a current of air; and are capable of being ignited, burning with a blue flame and leaving but little ash. At low temperatures, this polymerization may be to a great extent prevented by the addition of calcium chloride or other neutral substance to the solution of formaldehyde. The addition of formaldehyde to concentrated solutions of the fixed alkalies results in sweet-tasting compounds, the nature of which has not as yet been determined. A complex amine results from its addition to ammonia, and this reaction is utilized in the quantitative determination of formaldehyde and also as a means of rapidly removing all traces of this irritant gas from recently disinfected rooms.

Formaldehyde coagulates albumen, but when added to a solution of serum albumen it prevents it from coagulating by heat. It readily unites with the nitrogenous products of decay, fermentation and decomposition, forming true chemical compounds which are both odorless and sterile. It is thus a true deodorizer; in that it does not mask one odor by another still more powerful, but forms new chemical bodies which possess no odor. It is from this property of combining directly with albuminoids forming the protoplasm of micro-organisms that the gas is supposed to derive its powers as a germicide.

When formaldehyde solution is boiled with an alkaline solution of resorcin the liquid turns red. For the determination of the amount of formaldehyde in a solution De Schweinitz recommends a method depending upon the decomposition of hydroxylamine hydrochloride by formaldehyde in the production of hydrochloric acid, the quantity of which may be readily determined by titration with tenth-normal alkali solution. An amplification of this method is adapted to the determination of the quan-

tity of formaldehyde present at any one time in the air of a space undergoing disinfection.

Although there are several methods for its production, formaldehyde gas is probably best prepared by bringing the vapor of methylic alcohol, properly mixed with air, into contact with a metallic surface or fine metallic powder, or any fine powder which does not melt and upon which neither the air nor alcohol exerts any chemical action. The surface or powders must first be heated to a red heat—which temperature chemical union will afterward maintain. The chemical change involved depends upon the following reaction: $CH_4O + O = CH_2O + H_2O$. The metals or powders most employed are platinum, copper, copper and iron oxides and coke; the first-named probably being the best for this purpose. While theoretically about ninety-three per cent., by weight, of the alcohol should become formaldehyde, it is stated that the actual yield will not be over fifteen to twenty per cent. under ordinary conditions; the alcohol not usually being more than eighty per cent. pure and a large proportion of it being converted into CO_2 and other organic bodies during generation of the formaldehyde. Upon silk, woolen and cotton fibers, or upon any coloring agent outside of some of the little used aniline dyes, formaldehyde has no injurious effect. The dry gas has but slight action on polished metal, but its watery solution rapidly attacks and corrodes steel. The gas may be considered as being comparatively non-toxic to the higher forms of life and considerable quantities may be respired for a short time without ill effects. Still, it is well to observe a certain degree of caution in its use.

Formaldehyde in aqueous solution is on the market under various trade names, such as "formalin," "formal" and "woodine"—the latter containing an admixture of a considerable quantity of wood alcohol, which some manufacturers add to increase stability. The solid polymer is commercially known as "paraform" and is probably present to some degree in all formaldehyde solutions.

According to Stahl, the relative antiseptic value of formaldehyde, as compared with some of the commoner substances used as disinfectants, is as follows: Hydrogen peroxide, 1–20,000; mercuric chloride, 1–14,300; silver nitrate, 1–12,500; carbolic acid, 1–333; potassium permanganate, 1–285; boracic acid, 1–143; formaldehyde gas in solution, 1–25,000. The germicidal effect of formaldehyde in watery solution is thus compared by Park and Guerard:

Disinfectant.	Strength.	Bacteria.	Destruction of vitality.
Mercuric chloride	1–1,000	Anthrax spores	In 5 minutes.
Mercuric chloride	1–5,000	All other germs	In 15 minutes.
Silver nitrate	1–10,000	Anthrax spores	In 48 hours.
Silver nitrate	1–4,000	All other germs	In 2 hours.
Carbolic acid	3–100	Anthrax spores	In 48 hours.
Carbolic acid	1–300	All other germs	In 2 hours.
Tricresol	1–100	Anthrax spores	In 48 hours.
Tricresol	1–500	All other germs	In 2 hours.
Lysol	1–100	Anthrax spores	In 1 hour.
Lysol	1–100	All other germs	In 5 minutes.
Formaldehyde (40 per cent. sol.)	3–100	Anthrax spores	In 15 minutes.
Formaldehyde (40 per cent. sol.)	1–100	All other germs	In 1 hour.
Formaldehyde (40 per cent. sol.)	1–100	Most other germs	In 30 minutes.

According to Walter, a watery solution of one per cent. strength rapidly destroys all pathogenic micro-organisms; a somewhat longer time being necessary in the case of the spore-forming bacteria. Fæces are deodorized almost immediately—and are sterile at the end of ten minutes—when mixed with a solution of this strength.

Formaldehyde does not appear to be surpassed as a germicide and antiseptic by any other substance unless it be bichloride of mercury, while it possesses the invaluable advantages of not being retarded in action by albuminoid matter, of not injuring the articles to which it may be applied and of being safer for general use.

It cannot be too strongly emphasized that the efficiency of formaldehyde disinfection largely depends upon its intelligent supervision. The unsatisfactory results obtained by some observers appear to have depended upon different types of apparatus used, the temperature of the room, currents of air and many other factors. Hence conclusions based upon one type of apparatus should not be applied to other methods. The manner of applying the gas also appears largely to influence its efficiency, and better results appear to follow the liberation of a large amount in a short time than the generation of the same quantity in a longer period. A low temperature largely impairs the effectiveness of formaldehyde disinfection and the latter should not be attempted in a temperature below 10° C. Where possible, the room to be sterilized should be artificially heated during cold weather; as the germicidal action of the gas is more rapid and complete above 27° C. —the range between 10° C. and 27° C. appearing to make little difference with its action. A certain amount of moisture in the atmosphere is desirable, as it tends to retard repolymerization. In working with a gaseous disinfectant of this kind the currents of air must also be taken into account. On windy days, in rooms upon the exposed side of a building, the gas escapes so rapidly in spite of due care in sealing air-cracks that it is extremely difficult to obtain thorough disinfection; and, on account of air-currents, there are small spaces in nearly every room which are extremely difficult to sterilize. This gas being much more diffusible than sulphur dioxide, proportionately greater care is required in sealing up all cracks and crevices in room disinfection.

Formaldehyde appears to be an excellent and valuable surface disinfectant, but to possess only small penetrative powers under ordinary conditions. Park states that three times the ordinary quantity must be used to penetrate a single thickness of cloth; whence it follows that heavy fabrics should preferably be disinfected by steam, boiling or soaking in germicidal solution. It appears to be established that an exposure of not less than eight hours, at a temperature not lower than 10° C. and to a strength of formaldehyde gas not less than one per cent. by volume, will effect surface sterilization. Positive results may be obtained with similar amounts and shorter exposure, but they cannot be regarded as uniform under all circumstances. It should be understood that proportion of gas and time of exposure cannot well be separated. The time of exposure must vary as the amount—but it is a safe plan in practice to make the amount large and the time long. According to Fournier, the combination of acetone with formaldehyde greatly increases the penetrating power of the latter. The acetone has no bactericidal effect but merely serves as a mechanical

vehicle for the formaldehyde. He advises the preliminary treatment of the room with the vapor of a mixture of acetone and water, equal parts, followed after an interval of an hour by the use of the formaldehyde.

For the rapid generation of formaldehyde gas, outside the use of the spray already described, some special apparatus is required. As before noted, it may be slowly evolved by spontaneous evaporation from its watery solution; but any attempt to expel the gas more rapidly by boiling appears to result largely in the production of a polymer, which requires for its decomposition a heat considerably above that of boiling water. The generation of the gas in its direct production from methyl alcohol depends upon retarded combustion, and hence the ignition or the use of too great heat in the use of the alcohol simply results in the splitting up of that substance into elementary bodies without the production of formaldehyde. Since the solid paraform resolves into the original formic aldehyde at 135° C., it is evident that the application of too great heat may result in the complete

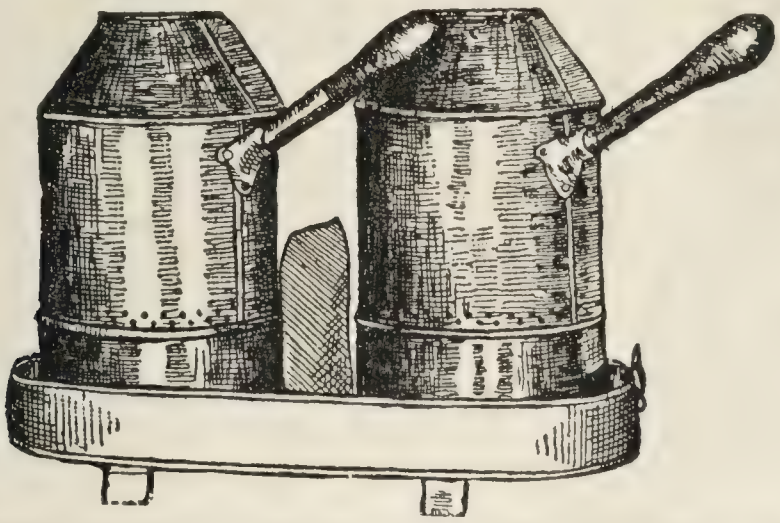


FIG. 363.—Bowdoin Apparatus for the Generation of Formaldehyde from Wood Alcohol.

combustion of paraform pastils without the evolution of formaldehyde in any considerable amount.

To meet the above conditions three types of apparatus, intended for the generation or liberation of the gas from wood alcohol, from a watery solution of the gas and from its solid polymer, are now on the market. A number of modifications of these original types have been constructed, but these do not differ essentially from each other. One general fault appears to be that the generators are too small, and hence too slow in action, to give full satisfaction in the disinfection of large rooms. On account of the great diffusibility of the gas, the best apparatus for room disinfection is that which can be relied upon to liberate the greatest amount of the gas in the least time and which combines simplicity with durability and cheapness. The main idea is to get the necessary proportion of gas into the room in the shortest possible period. Hence, in the sterilization of large spaces, it is well, if the type of apparatus be small, to operate several generators simultaneously.

The simplest apparatus in which wood alcohol is directly converted into formaldehyde is that known as the Bowdoin generator. In this apparatus the fumes of wood alcohol contained in a receiver are passed through a collar of hot platinized asbestos. In the operation, the alcohol in the receiver is ignited and the asbestos collar held over the flame until incandescent, usually requiring about half a minute, and is then dropped over the

receiver, smothering the flame. The heat already created, however, continues to volatilize the wood spirit, which, passing through the asbestos, maintains its incandescence and is itself decomposed into formaldehyde—the operation continuing automatically until the supply of alcohol is completely exhausted. This apparatus does not yield by any means the amount of formaldehyde gas theoretically possible; the loss probably being due to the great difficulty of maintaining the asbestos at a constant temperature. As a result, a considerable portion of the alcohol suffers complete combustion in the production of bodies of no germicidal value. The apparatus described is both cheap and simple, but has necessarily to be abandoned in the room to be disinfected. Careful investigation has shown that by its use about fifteen per cent., by weight, of the alcohol used will be converted into formaldehyde; hence requiring as a minimum 500 cubic centimeters of wood spirit for each 1,000 cubic feet of space to be disinfected. The Marine Hospital service requires the use of 750 cubic centimeters for each 1,000 cubic feet and the employment of a generator capable of converting one liter of wood alcohol into formaldehyde per hour. The cost of operating this form of apparatus, on account of wastage, is somewhat in excess of those using formaldehyde in watery solution or the solid paraform. With this method, the amount of ammonia required for neutralizing the formaldehyde after the completion of disinfection can be evolved by heating or spraying one part of water of ammonia for each part of wood alcohol used.

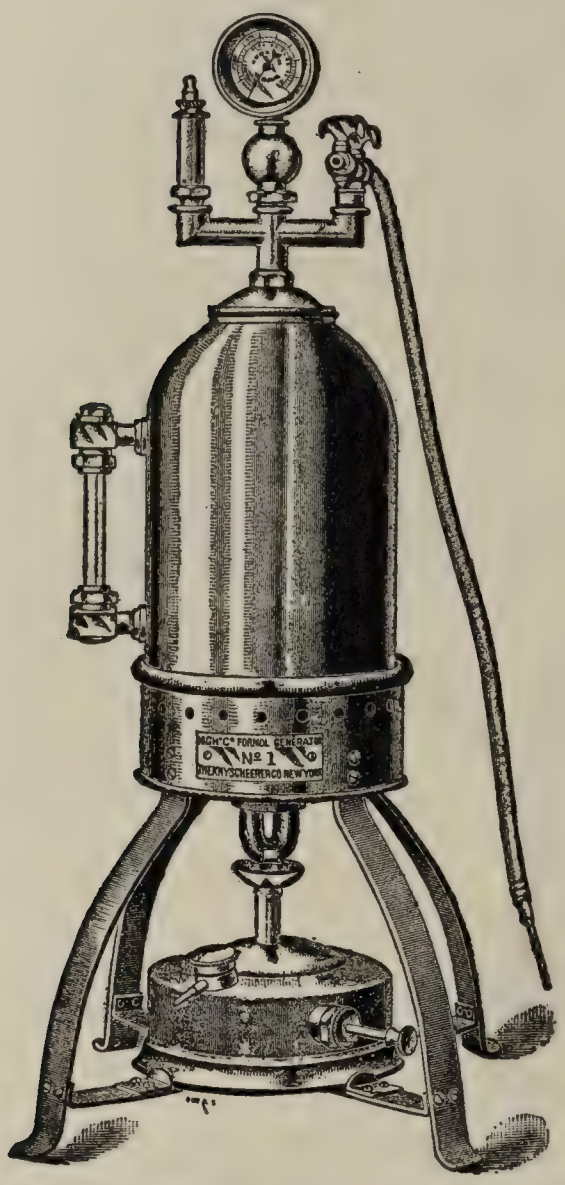


FIG. 364.—Kny-Scheerer Apparatus, for the Liberation of Formaldehyde from its Watery Solution.

Of the appliances for expelling formaldehyde from its watery solution, the Trillat autoclave is the original type from which a number of modifications have emanated. In the use of formaldehyde in solution, known under the various trade names of "formalin," "formochloral" and "formal," it is necessary to bring such solution to a minimum temperature of 135° C. to prevent repolymerization. Hence the employment of the autoclave, in which it is readily possible to create an internal pressure of three or four atmospheres before permitting the outflow of any of the gas. This apparatus also has the practical advantage of causing the sudden influx of a large quantity of gas into the apartment to be disinfected, and as the formaldehyde may be readily conducted through a tube wherever wanted and the apparatus manipulated outside the room, the latter is consequently always

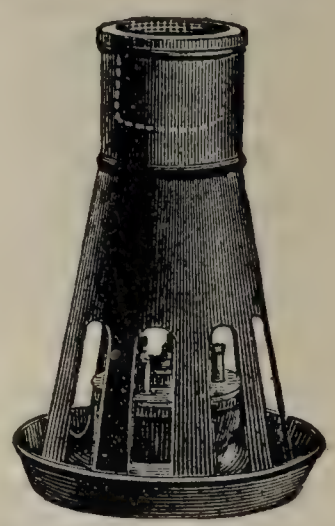


FIG. 365.—Schering and Glatz Lamp, for the Generation of Formaldehyde from the Solid Paraform.

under the supervision of the operator. An improved form of Trillat's generator is that of the Kny-Scheerer Company, at present supplied in the United States army, which appears to possess all the qualities for room disinfection; being simple in construction, safe in operation and requiring no great original outlay. Strüever has shown that only about seventy-eight per cent. of a forty per cent. solution of formaldehyde can be actually obtained for disinfection purposes. Since allowance for the gas escaping from the room must also be made, it will scarcely be safe to use with this apparatus less than 350 cubic centimeters of formalin per 1,000 cubic feet; the cost of disinfection with this apparatus being about eleven cents per thousand feet. For neutralization of any remaining formaldehyde after the use

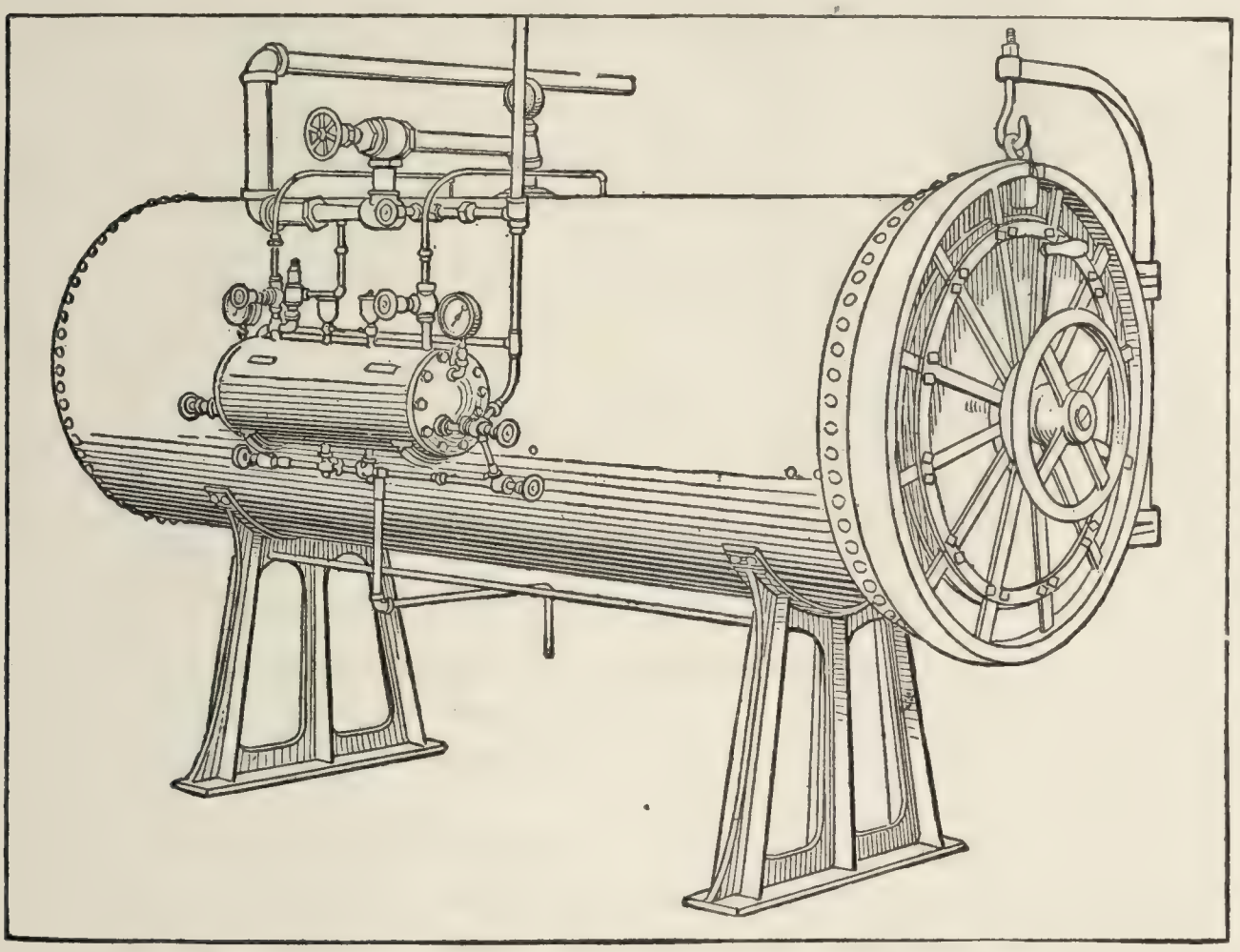


FIG. 366.—Formaldehyde Chamber, for the Disinfection of Small Articles.

of this method, 1.25 liters of water of ammonia should be employed for each liter of formalin used.

For the vaporization of the solid paraformaldehyde, compressed into pastils, the Schering and Glatz lamp has been constructed. The operation of the apparatus is simple, and consists merely in the application of heat to the necessary number of pastils when placed in the cup of the disinfector. This method of generation is cleanly and convenient, but is somewhat more expensive than the preceding. At present the lamps on the market are small and scarcely adapted to the disinfection of large spaces, but are admirable for the sterilization of instruments and similar articles. Care must be taken not to apply too great heat to the paraform pastils, since otherwise these decompose in the production of bodies other than formaldehyde. The cost of sterilization with this lamp is about twenty cents per thousand feet. For success with the use of this solid isomer not less than one gram should be volatilized for each twenty cubic feet of space. To neutralize completely

the resulting formaldehyde, one liter of water of ammonia for each 150 grams of the solid used must be employed.

For the disinfection of articles which are too valuable to be destroyed by fire and which cannot be rendered germ-free by other means without injury, certain special chambers for disinfection with formaldehyde have been designed. In such chambers, with the high proportion of the gas which can be secured, penetration to a satisfactory degree can be obtained with bulky articles. The previous creation of a partial vacuum of course materially assists the penetration of the formaldehyde. The objection to a small chamber, if the gas be expelled from its watery solution, is that moisture from the evaporation of the water collects on the inside of the chamber and wets the goods where they come in contact with the walls. The gas should hence be preferably applied in the dry state in a strength of not less than twenty per cent. by volume, and the time of exposure should not be less than one hour.

In the absence of any specially constructed chamber, and particularly for use in the field, an excellent disinfection chamber may be made from

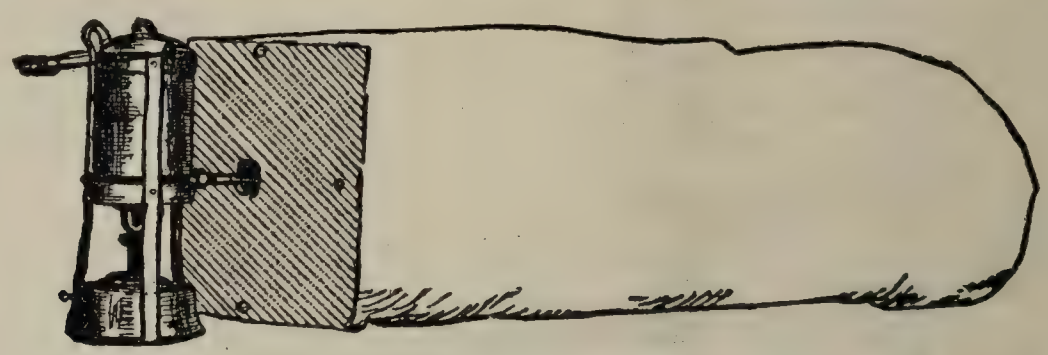


FIG. 367.—Improvised Disinfecting Bag with Formaldehyde Generator, for Field Use.

a large box the seams of which have been tightly caulked; or by the use of a large canvas sack the exterior of which has received several coats of white lead. The operation of this arrangement is shown in the accompaying illustration.

Formaldehyde gas is superior to sulphur dioxide as a disinfectant for dwellings because it is more efficient and rapid in its action; because it is less injurious in its effects on household goods; because it is less toxic to the higher forms of animal life; because, when supplied from a generator placed outside of the room and watched by an attendant, there is less danger of fire. Apart from the cost of the apparatus and the greater time involved, formaldehyde gas, generated from commercial formalin, is not more expensive than sulphur dioxide, viz.: eight to ten cents per thousand cubic feet being approximately the cost of the disinfectant in either case.

SPECIAL APPLICATIONS OF THE DISINFECTIVE PROCESSES.

Room Disinfection.—In the disinfection of habitations, the processes are not as yet perfected nor do the problems presented always appear easy of solution. The disinfection of a closed space is a complex operation, implying not only contact with germicidal substances in gaseous form but also mechanical cleansing and the application of disinfectant solution. Hence, on the account of the necessity of evacuation by the occupants and the arduous nature of the processes of disinfection as applied to habitations,

the employment of the latter should usually not be advised in the absence of ample justification for such action.

In the routine method for the disinfection of a room the sealing up of all its openings and its fumigation should precede all other treatment. When properly carried out, a large proportion of the infectious germs, even if not all, are destroyed by this process; rendering their dissemination in the subsequent steps of the operation less liable to occur, as also the contraction of disease by the persons engaged in the work of disinfection. The gaseous agent selected should if possible be either sulphur dioxide or formaldehyde—and of these, preferably the latter. After sealing up all cracks from the outside, and the preparation of the room and its contents in the manner best calculated to assist the germicidal action of the gas, the operation of fumigation is carried out in the manner already described. Usually the formaldehyde generator is placed just outside the door and the gas passed into the room through the keyhole. After sufficient exposure to the gas, the room is thrown open and thoroughly aired, small articles as clothing, fabrics or furniture being removed for such further treatment for their disinfection as may be appropriate. If formaldehyde is used, any excess of gas in the room may be neutralized by ammonia sprayed through the keyhole before entrance.

The nature of the wall determines the method to be employed for its disinfection. If painted in oil a simple washing or spraying with a disinfectant solution, in connection with fumigation, will give satisfactory results. Wainscoting should receive the same treatment as flooring. Papered walls should have all layers of paper removed, be washed or sprayed with a germicidal solution, preferably a five or ten per cent. filtered solution of chlorinated lime, and then be re-papered. Calcimined or whitewashed walls should be cleansed, washed with a solution of chlorinated lime and thoroughly re-calcimined or whitewashed. An excellent method for the mechanical cleansing of walls consists in the employment of pieces of stale bread, into which the adherent dirt and bacteria are incorporated by rubbing. After the operation, all crumbs and fragments of the bread are carefully collected and burned. While excellent results are attained by this method, as well as by the use of cloths wet in disinfectant solutions, properly to rub down the walls of a large room requires the expenditure of much time and labor. For the disinfection of walls the removal of plaster is not necessary; but barrack and hospital walls should always be impermeable to moisture to facilitate their disinfection.

Bacterial life is naturally much more abundant on the lower than the higher portion of walls; thus the number of germs present near the floor of a stall examined by Duclaux was ten times greater than at an elevation of one meter. It is quite often considered that the ceiling is not infected, since it is evidently so much less exposed to contamination than the floors and lower portion of the walls. Still, a certain amount of dust and particulate matter is always adherent to the ceiling and hence the latter should receive its share of attention in the process of disinfection.

Woodwork, such as doors and window-frames, should be cleansed with soap and hot water, washed with a solution of bichloride of mercury and repainted when dry. After any débris present has been dampened and carefully removed, the floor should be cleansed with soapsuds or strong lye and

then thoroughly scrubbed with a standard solution of mercuric chloride or tricresol, particular attention being given to the treatment of all joints or cracks. For this purpose an unnecessary amount of fluid should not be employed, since the germicidal properties of the agents used are soon destroyed—the coal-tar products by evaporation and mercuric chloride through its affinity for organic matter—and the remaining moisture favors subsequent bacterial development. Disinfection of ordinary floors is not always a simple matter owing to the number of crevices, filled with organic matter and detritus, which afford protection to micro-organisms and offer a favorable medium for their development. For this reason, wooden flooring should always be made of carefully matched and seasoned material and should then be rendered impervious by one of the methods described in a previous chapter. Floors so prepared are readily disinfected by simply mopping with some suitable solution.

Stone or tile floors are disinfected in the manner above described. If stone floors are in bad condition, after the removal of all dirt from cracks and crevices and their careful disinfection, it is desirable that a solid new flooring of cement, asphalt or concrete should be superimposed.

Dead spaces between floors, if tight, are preferably disinfected by the use of formaldehyde gas, generated in the autoclave apparatus. If open to the air and infection appears probable, a few floor boards may be removed and the interior washed or sprayed with a filtered solution of chlorinated lime of ten per cent. strength.

Exposure of the room to the action of the sunlight and to free perflation by the air, for several days following the completion of the processes of disinfection, is always desirable.

Disinfection of Stables.—Prior to the application of the processes of disinfection to the structure itself, all small articles are to be removed; such as have possibly undergone contamination, particularly buckets, curry-combs, brushes and such horse equipment as may have come in contact with sick animals or with infectious material, should be promptly sterilized. Metallic objects or utensils, after a thorough preliminary cleansing with soap, a stiff brush and hot water, may be sterilized by boiling or else by being immersed or washed in a five per cent. solution of carbolic acid or a two per cent. solution of tricresol. Leather articles, as harness or equipment, should receive a similar preliminary cleansing and either be scrubbed with a solution of bichloride of mercury 1–1,000 strength, a strong solution of carbolic acid or tricresol, or be subjected to the continued action of formaldehyde gas. Blankets and horse-covers may be disinfected by soaking for several hours in a strong solution of mercuric chloride 1–800, renewed according to necessity. They should then be dried in the open air and, if possible, subsequently washed.

For the disinfection of the stable itself, all hay and grain should be removed from racks and mangers and all bedding from the floors. After its careful collection at some designated point, this refuse should be saturated with mineral oil and destroyed by fire. All interstices in the floor and walls should be scraped out and the débris removed, carefully swept up and burned. The woodwork should be cleansed throughout with hot lye or strong soft-soap solution, following which all mangers, hay-racks, stall partitions, floors and walls are to be thoroughly scrubbed with a one per

cent. solution of tricresol applied vigorously with the aid of a stiff brush; care being taken that all parts of any cracks or crevices are penetrated. After several days' exposure to air and sunlight the interior of the stable should receive a coat of whitewash, applied thickly and prepared from lime freshly burned shortly before the time of use. After the completion of the processes of disinfection, the stable should not be re-occupied for several days to permit of thorough drying, airing and the disinfectant action of the whitewash.

Horse troughs used for the watering of animals are, when infected, to be emptied of their contents. If not connected with a drain or sewer, the water should be sterilized by the addition of a proper amount of a suitable disinfectant before being poured upon the ground. Cleanliness of the troughs should be thoroughly accomplished and all organic matter, animal or vegetable, removed and disinfected by fire or by immersion in some strong germicidal solution. For metal-lined troughs the use of acid solutions or bichloride of mercury is of course inapplicable, and such may be disinfected by the use of one of the coal-tar products. Wooden troughs may be treated with an acid solution of mercuric chloride. The operation is completed by a thorough flushing of the trough with a large amount of clean water and by exposure to the sun and air, in a dry condition, for forty-eight hours. All pipes or carriers of the overflow water should be carefully disinfected with five per cent. carbolic acid solution.

Disinfection of Wells and Cisterns.—It is not necessary to emphasize the fact that, where possible, all suspicious water-supplies should be avoided; but circumstances may arise by which a well, the only readily available source of supply for an isolated military camp or station, may be temporarily infected and seriously inconvenience the users of the water, unless some safe remedy is at hand. To meet the requirements of such cases, efforts have been made to determine how far it is possible to disinfect wells; with the result that this has been shown to be practicable, providing the contamination has not been great and is not continuous. The method recommended for the disinfection of wells which have been only temporarily polluted, as by the accidental deposition into them of infective matters from above or the washing into them of such material by storm-water, consists in pouring a mixture of equal parts of crude carbolic acid and sulphuric acid into the well until it is present in the proportion of about five per cent. of the total contents. The mixing of the whole should be thorough, and the walls of the well should be scrubbed with brooms dipped in the solution. The inside of the delivery pipe should be thoroughly cleaned by flushing with the solution and scrubbing with a long-handled brush wet with the same disinfectant. After standing for twenty-four hours the contents should be pumped out, the slime from the bottom thoroughly removed and the well allowed to refill. This process is repeated until all traces of the acid have disappeared.

Disinfection of wells is also practised by the use of freshly burned lime. About half a barrel of lime is thrown into the well, stirred up with the water and the walls are scrubbed down with the resulting milk of lime. The well is then pumped out, cleaned, allowed to refill and a second supply of lime added; after which the well is allowed to stand for twenty-four hours. After a thorough stirring the solution is then pumped out,

and the well is allowed to refill and is re-emptied until the water removed is practically free from lime. The delivery pipe is scrubbed with strong carbolic-acid solution.

For drinking purposes alone, all water that is of necessity derived from suspicious sources should be boiled before use. No process of disinfection of wells can replace this precaution, and the former is of value chiefly as it removes the danger of indirect and accidental infection from the use of the water for bathing, washing and domestic purposes.

Disinfection of Tentage.—As with other habitations, temporary evacuation is an essential preliminary to the disinfection of tentage. After removal of all contained articles for their disinfection by appropriate methods, the tents, while standing, should be sponged or sprayed with a two per cent. solution of tricresol or a four per cent. strength of carbolic acid. The lower portion of the canvas walls, together with the sod-cloth, should receive a particularly thorough wetting—outside as well as inside. The tent poles should be washed with the same solution and the flooring, if any, taken up and subjected to the same treatment. The site of the tent having been thoroughly policed, it may be well sprinkled with a ten per cent. solution of chlorinated lime; or calcic oxide may be so scattered over the space as to form a thin layer, the lime being immediately slaked *in situ* by the use of a spray or watering-pot. Flooring, as well as the interior of the tent, should be exposed to the air and sunlight for several days. The floor should not be laid down until the necessity for such action becomes urgent through the intended early re-occupancy of the tent, when a new location for the latter should be selected. A much more desirable method, but one implying infinitely greater labor, consists in the striking of all tents and the sterilization of their canvas by boiling in large improvised vats. After thorough washing of tent poles and floors with tricresol solution, the camp should preferably be established at some uninfected point and the former site abandoned.

Disinfection of Clothing.—The processes of disinfection must be carried out with special care when applied to articles of clothing or bedding; since such objects, which have been in close contact with the persons of the sick, are necessarily particularly dangerous through the greater amount of infectious material with which they are permeated.

Clothing, bed-clothing and similar articles, when infected, should be placed in tight receptacles or rolled in sheets wet with some germicidal solution to avoid dissemination of morbific matter during transportation to the place of disinfection; or special sacks might be kept on hand for this purpose, as is the custom in the French army. Such articles should of course be unrolled or removed from the sacks prior to the commencement of the process of disinfection.

All articles belonging to the soldier which are made of cotton, such as shirts, stockings or towels, may be sterilized by any of the accepted methods. On account of its comparative simplicity and readiness of application, immediate immersion in a strong disinfectant solution with subsequent boiling and washing best answers all purposes. In time of epidemic a suitable water-tight receptacle, containing some strong disinfectant solution, should habitually be kept outside the ward in which infectious cases are receiving treatment. All infected articles should be at once

submerged in this solution and allowed to remain until their removal to the laundry, where boiling of the articles in soap-suds or a weak soda solution should be performed before washing.

When soiled by evacuations, secretions or excretions, the method of disinfecting bed or body linen is somewhat different. Infected articles thus contaminated should be immersed in a solution made up of three parts of carbolic acid, two parts of ordinary soft soap and one hundred parts of cold water. They should be allowed to soak in this solution for two hours and then be rinsed out before being subjected to the ordinary laundry processes. The reason for this immersion in cold carbolized-soap solution is that it not only destroys all non-sporulating bacteria but also dissolves out blood and fæcal stains; the latter being rendered indelible by coagulation of their albuminous constituents, if the soiled articles should be at once exposed to steam, boiling water or corrosive sublimate solution.

Articles of woolen material, as uniform blouses, trousers or flannel shirts, should not be disinfected by boiling on account of the resulting shrinkage of the fabric; the use of flowing steam and simple immersion in disinfectant solution not being entirely free from the same objection. Woolen wearing apparel, well spread out, is disinfected with the least deterioration of quality by the use of formaldehyde gas, the employment of which for this purpose has already been outlined. Superheated steam is much employed for this object and gives excellent results. In its use the clothing should be loosely hung up on hooks in the chamber, the temperature raised to 110°–112° C. and maintained at that point for twenty minutes. In the British service an exposure of one hour to a temperature not less than 105° C. is required. Clothing which has been disinfected by superheated steam should not be allowed to remain in the apparatus, but should be hung in the open air to dry so as to avoid the production of creases. Disinfection of fabrics by means of sulphur dioxide may be satisfactorily employed with all articles which, through their nature, suffer deterioration or injury on exposure to dry or moist heat or on immersion in disinfectant solutions. In selecting a room for such purposes it should be no larger than the probable necessities demand, nor should it be in any occupied habitation on account of the discomfort which would otherwise be caused among the inmates. It should have impermeable walls and floors and the windows and doors should be capable of being hermetically sealed. Since the sides of wooden boxes are easily penetrated by sulphur dioxide gas, their use gives unsatisfactory results unless they are well papered on the inside with stout and preferably glazed paper. The articles to be disinfected are hung up in the chamber and are so disposed as to present the greatest amount of surface to the action of the gas. Exposure should last for thirty-six hours, at the end of which time the articles should be thoroughly sunned and aired. For the disinfection of clothing by sulphur dioxide its generation from the liquid state is preferable, and its presence in considerable strength, favors penetration of fabrics. Disinfection by sulphur dioxide is applicable to all fabrics although, in concentration of four per cent. and particularly in the presence of moisture, it has a tendency to fade colors. This is to some extent the case with the sky-blue kersey uniform trousers. Bed-clothing, when disinfected with sulphur, may long retain an extremely disagreeable odor of hydrogen sulphide. Spraying with a ten per cent.

strength of formalin solution gives excellent results if due care and thoroughness be observed throughout the operation, and the articles are hung up for some hours in a small, tight space. If immersion of woolen fabrics in a disinfectant solution becomes necessary in the absence of better methods of disinfection, the solution employed should not contain a free mineral acid, it should be cold, the garments should be submerged without rubbing and should be allowed to dry in the open air without wringing or other unnecessary manipulation.

Under all circumstances, but particularly in time of epidemics, the sterilization of the personal apparel of the soldier, where required, should be accomplished as promptly as possible. An excellent rule is promptly to disinfect the wearing apparel of all men who enter hospital for treatment, irrespective of the cause of their entrance.

Disinfection of Excreta.—Fæcal matter of an infectious character is ordinarily disinfected by the application of germicidal substances in solution. Vessels intended to receive these matters should contain in advance a sufficient quantity of the solution selected; and, upon receipt of the infectious material, should be sufficiently agitated thoroughly to mix the contents, covered and allowed to stand at least one-half hour before being emptied and cleansed. Absolute sterilization is to be obtained only by thorough mixing, a procedure, even with small quantities of fæcal matter, which is extremely unpleasant as well as somewhat difficult of accomplishment. With large amounts of fæces, attempts at disinfection will in practice generally give results which in their nature are partial rather than absolute.

The best disinfectants for fæcal matters are such as possess, in addition to cheapness and strong germicidal qualities, the property of destroying bad odors. It is better that such chemical change be induced as will actually destroy odors of this character rather than mask one bad smell by another still more powerful. For the destruction of fæcal effluvia a strong solution of the sulphate of iron, though possessing but comparatively feeble germicidal powers, best answers all indications. The use of chlorinated lime serves an excellent purpose, except for the disagreeable odor possessed by this substance itself. It is well to remember, in this connection, that foul odors are always to be prevented by the maintenance of strict cleanliness, and that their existence necessarily implies an absence or an incomplete execution of those sanitary provisions by which the highest condition of health can only be maintained.

Dry earth possesses no antiseptic qualities and merely promotes the desiccation and decomposition of excrement while absorbing the odor. Corrosive sublimate solution of 1–1,000 strength, when mixed with equal parts of fæces, neither destroys the odor nor accomplishes disinfection, while a five per cent. solution of carbolic acid, added to a similar bulk of fæces, does not render the latter sterile at the end of an hour. Tricresol, however, is a valuable agent for this purpose, since its activity is not impaired by the presence of albuminous matter. In a strength of one per cent. this substance is something of a deodorant as well as actively germicidal. For the destruction of the typhoid bacillus a mixture of copper sulphate and sulphuric acid, each in two per cent. strength, is said to be particularly efficacious.

From determinations made by Vincent, the efficiency of the various disinfectants officially provided for use in the army of the United States, as regards the sterilization and deodorization of fresh or decomposing fæcal matter, would seem to be as follows:

	Deodorizing power.	Quantity of Disinfectant Required.	
		For the disinfection 1,000 c.c. of fæcal matter in twenty-four hours.	For each man daily, when considered as the unit of a large body in the field.
Chlorinated lime.....	Very good..	10–16 gm	17–28.3 gm.
Lime (calcium oxide).....	Fair	100 gm.	
Labarraque's solution.....	Good	250 gm.	
Carbolic acid	Good	30 gm.....	35 gm.
Bichloride of mercury, 1–1,000 acid solution	Poor.....	More than 200 c.c ..	More than 350 c.c.
Sulphate of iron	Very good .	More than 200 gm..	More than 340 gm.

For the disinfection of small quantities of fæces the use of a solution of tricresol, two per cent. strength, would seem to be most applicable. For the disinfection of latrines the employment of chlorinated lime or freshly burned lime (calcic oxide), with the use of sulphate of iron when required, is advisable on the ground of cheapness, germicidal efficiency and deodorizing properties.

In permanent barracks with water carriage and modern plumbing an attempt at the disinfection of the discharges is unnecessary, except during epidemics. When this appears to be advisable, the water-closets should be thoroughly scrubbed with a five per cent. carbolic acid or a two per cent. tricresol or chlorinated lime solution. Sufficient of the solution should be passed into them to fill the traps completely, and leave a quantity of the disinfectant in the body of the fixture. Care should be taken after concluding this procedure that no infected discharges again find their way into the closets, but all discharges of this nature should be carefully sterilized before being thrown down the hoppers.

The disinfection of urinals is accomplished by the same means as is that of water-closets, except that milk of lime should not be used for this purpose.

For the disinfection of infected fæces and urine, these should be passed directly into a five per cent. solution of carbolic acid or a two per cent. solution of tricresol. When milk of lime is used, the excreta should be mixed with a double volume of this material. Whatever the disinfectant solution used, care should be taken that this and the fæcal matter are well mixed and the whole should be covered up and allowed to stand for half an hour to one hour. The mixture may then be diluted with hot water and poured slowly into the water-closet—the flush of which should be allowed to run at the same time to prevent clogging of the trap.

The disinfection of privy pits and latrine trenches may often be required. While the first should not be tolerated at a military post, they may be best and most satisfactorily disinfected by the use of milk of lime, made up in the proportion of at least two per cent. of the contents of the vault; or it should be added and thoroughly mixed until the entire mass is strongly alkaline to litmus paper. By beginning with an empty and

clean privy-vault and adding the lime mixture daily, not only is the odor prevented but the mass is continuously disinfected. Sulphate of iron is very efficient in destroying bad odors generated under such conditions. For the disinfection of latrine trenches the above methods may be employed; but, as already mentioned, an excellent means of accomplishing disinfection under field conditions consists in a daily burning out of the trenches by the combustion of leaves, straw, dry grass or manure, scattered over the contents and sprinkled with petroleum.

The ideal ultimate disposition of infectious fæcal matter is by cremation in special apparatus. Unfortunately this method of disposal is usually not practicable except on a small scale; and even then implies the outlay of considerable additional effort and expense. Its use, however, in connection with the administration of hospitals in the field should always be resorted to, particularly in time of epidemic; the exercise of a little ingenuity readily permitting the construction of forms of apparatus which, though crude in detail, may give eminently satisfactory results in operation. These have been discussed to some extent in a previous chapter.

The sputum of cases of tuberculosis and diphtheria, and probably also that of pneumonia, is an important agent in the propagation of disease from the infected individual. Such sputum, particularly when of a tuberculous nature, is much more dangerous when dried than when in the moist condition; hence the great object is to maintain the sputum in the latter state until the time of its destruction. For this purpose cuspidors should be freely distributed throughout the barracks. They should, while in use, receive a daily disinfection and cleansing and should at all times contain a sufficient quantity of germicidal solution. The use in cuspidors of solutions of carbolic acid and mercuric chloride is not, however, of advantage, since both coagulate mucus and the former, in addition, possesses an unpleasant odor. Probably the use of fresh milk of lime is best for this purpose.

Sputum is best disinfected by the application of moist heat. Boiling water almost instantaneously destroys the tubercle bacillus while in the wet condition, but exposure to its action for a much longer period is required for its destruction after desiccation. In ordinary practice, cuspidors may best be sterilized by immersion in boiling water for a period of ten minutes. Sputum which has become hardened and adherent to the receptacle through drying may be loosened by the use of a solution of lye or other strong alkali.

Miscellaneous.—Articles of wood may be disinfected by washing with a germicidal solution or by exposure to a gaseous disinfectant. Leather cannot be disinfected by steam without undergoing severe injury, and articles as harness, horse equipment, boots or shoes must hence be disinfected by other measures. A mechanical cleansing preceded by the application of or immersion in some germicidal solution is the method usually employed, but this is probably inferior to disinfection by means of formaldehyde gas. Cooking or eating utensils are preferably disinfected by immersion in boiling water, as are also objects of metallic nature. Musical wind instruments are best sterilized by boiling, the mouthpiece being removed and receiving special attention. Wooden musical instru-

ments, which cannot be boiled, should be taken apart, cleansed and sponged with formalin. Wagons and ambulances may be disinfected by thorough preliminary cleansing with soap and hot water, followed by the application of some suitable germicidal solution by sponge, brush or hand pump.

Disinfection of the Person.—Attempts at disinfection of the persons of the sick—whether it be by the use of disinfectant ointments in scarlatina, gargles, sprays and mouth washes in diphtheria or medication calculated to asepticize the fæces and urine in typhoid fever—while in every way praiseworthy, may be considered as entirely lacking in that completeness of action upon which the definition of the term disinfection depends. While such efforts may have considerable inhibitory effect, as regards the vitality, propagation and dissemination of the specific germs extruded from the organism, this effect is only temporary, and the most painstaking endeavor fails entirely to reach the systemic foci from which myriads of infectious bacteria are constantly being discharged. Disinfection of the person of the sick will therefore be accomplished only as a result of processes occurring in the individual himself; depending upon his vital resistance and his powers of destruction and elimination, through the formation of antitoxins, as regards an invading and infectious microorganism.

The disinfection of the person of the convalescent within whose organism, through an acquired immunity, the forces of an infectious disease have ceased to act, as well as with regard to the healthy individual, who may be temporarily the vehicle of infectious matter, is, for all practical purposes, capable of accomplishment. The process includes the attainment of thorough personal cleanliness through the use of hot water, soap and flesh or nail brush, the shampooing of the hair and beard with borax and the application of a solution of mercuric chloride, 1–3,000, to the entire surface of the body—a solution made up of one part of Labarraque's solution to nineteen of water also being excellent for this latter purpose.

The Sanitary Officer and His Assistants.—The various processes which go to make up the procedure known as disinfection require, above all things, exactness and attention to small details to ensure ultimate success. Hence the sanitary officer will not relieve himself of the responsibility for such a delicate and important operation if with a few vaguely worded and ill understood directions the matter is turned over to enlisted subordinates, who, faulty in their technique, are absolutely ignorant of the scientific principles underlying the processes which they are called upon to perform. The sanitary officer himself should personally superintend and direct the operation of disinfection. He should have careful supervision over the preparation as well as the employment of the various agents used, should minutely instruct those engaged in the work in the proper performance of their duties and the dangers to which they themselves may be exposed, and his should be the responsibility for any accidents during the operation. He should specifically name all articles and places to be disinfected and he should make sure that his orders are obeyed in the spirit as well as the letter.

As far as possible, all work of disinfection should be done by the men of the Hospital Corps; although, if considerable rough labor be necessary, a certain portion of it may safely be delegated to such soldiers of the line

as may be detailed for such duty under the orders and control of the sanitary department. All individuals engaged in the work of disinfection should wear complete outer clothing of cotton duck which, on ceasing work, may be removed and sterilized by boiling, steaming or soaking in disinfectant solution. Under no circumstances should clothing be worn in the constant contact and close relation of the camp and barracks, which has served the soldier for use while engaged in the process of disinfection. At the end of each day, or on concluding the task, the hands, face, hair and beard should be washed and disinfected, a general bath should be taken and clean clothing donned. Eating and drinking, during the continuance of the processes of disinfection, by those who have the operation in charge, is always to be avoided.

CHAPTER XVII.

THE HABITS OF THE SOLDIER AS AFFECTING HIS EFFICIENCY.

ALCOHOLISM.

The attitude of the recruit toward the use of intoxicating liquors is largely determined prior to his entrance into the military service; but that a few soldiers become drinking men after enlistment, as a result of social environment, in the army as in civil life, cannot be denied. To this end the common practice of "treating"—used as an expression of hospitality or social courtesy, often under circumstances when liquor may not be desired by either the recipient or donor—contributes not a little; and to drink and ask the companionship of others in consuming alcoholic beverages is the first step toward the development of the confirmed drunkard. Further, the idea that social superiority attaches to an ability to consume large quantities of alcoholics still exists to a certain extent among soldiers of a lower and more depraved class, and by such a novice in the art of drinking may not rarely be assailed with ridicule and contempt. Such men, now fortunately few in our army, are largely responsible for the idea which occasionally obtains among recruits, that a physical tolerance of alcohol is an essential attribute of the soldier and that only he who is able to imbibe his share of intoxicant without apparent effect has demonstrated his fitness to enter upon the profession of arms. Some few soldiers undoubtedly acquire the habit of taking alcoholic stimulants largely as a result of favorable opportunity, particularly if they are men without aim or purpose in life beyond the perfunctory accomplishment of routine duties—men who are possessed of no internal resources for their amusement and to whom the normal existence is burdensome, dull and monotonous. A still smaller class of soldiers appears to be markedly influenced by atmospheric conditions, with respect to alcoholics; and prolonged exposure to heat, cold and moisture have frequently been observed to develop, in such men, a latent desire for drink which probably otherwise would have remained dormant. A certain number of periodical military drunkards are true degenerates. Without apparent cause, in the face of promises and protests to the contrary and in spite of the knowledge of inevitable court-martial and disgrace, alcoholic excesses are begun and continued until exhausted nature brings the debauch to a close. Then follow deep contrition and humiliation, renewed and earnest promises of reform and an apparently sincere attempt to repair the damage done to health and character, a period of decorous life, and again a plunge into excess. The greater proportion of inebriates, however, as found in the military service, appear to be men of unstable mental equilibrium, indecision and weak character. Such, under any conditions out of the ordinary,

find the mental strain beyond their power of endurance and promptly seek relief in the nerve-benumbing effects of alcohol.

Of recent years, the idea has been advanced that the drunkard is not always responsible for his acts; that he may be physically and morally defective and should be treated not as an offender but as a sick man subject to a species of insanity. This idea, accepted by many as explaining and excusing all cases of alcoholism, is highly misleading and is applicable only to a restricted class in which inebriety is but one of the several outward manifestations of an ill-balanced mentality. It is safe to consider that the tendency toward alcoholism, instead of being a specific disease which drives its victim to some form of narcotic excess, simply expresses a defect in the nervous organization which makes his condition or existence more pleasurable or less painful during intoxication than during abstinence. Finally, according to Crothers, inebriety is distinctly favored by malnutrition; and hence uniformity in the time of taking food, as well as its good quality and ample variety and amount, should be the constant care of the company commander.

No small proportion of soldiers who would resent the title of drunkard, take a quantity of alcohol daily sufficient to maintain a certain state or degree of stimulation for months at a time, exhibit no special peculiarities of conduct and attend to their duties with the utmost regularity. Such usually die from—or are discharged by reason of—some acute inflammation or chronic disease largely dependent upon alcoholic irritation. While it is obvious that any attempt at defining the limitations of this class must be purely arbitrary, it is considered by many authorities that any man drinking on an average more than two ounces of pure alcohol during the twenty-four hours—whatever be the form in which it is absorbed—may be included in this category.

Prevalence of Alcoholism.—In the military service, the abuse of alcoholic liquors is one of the most potent factors by which efficiency is impaired; and in the past, its effects were so apparent that drunkenness was largely looked upon as a distinctively military failing. Its influence as well as its prevalence is indifferently shown by military statistics; for all drinking men do not enter hospital for alcoholism, and a certain proportion of drunkards succumb to such various diseases as gastritis, cirrhosis of the liver and nephritis, in the development and ultimate result of which the use of intoxicants has probably played no minor part; further, the term alcoholism includes many pathological conditions and their symptoms, these varying according to the quantity of alcohol taken and the manner in which it is consumed. Chronic drunkenness occurs chiefly among old soldiers, and these steady drinkers, although their rates are higher, are not proportionately represented on sick report as compared with younger men, among whom the use of intoxicants more frequently occurs in the nature of periodical excesses requiring medical treatment. Acute alcoholism not rarely terminates life, and even at as recent a period as the decade 1886–95 it stood sixth in order of importance in determining the mortality among the white troops of the United States army. The proportion of discharges and constant non-efficiency from this cause is, however, low.

The rates for alcoholism in our service have steadily decreased in the past fifteen years; this having been accomplished through greater care in

the selection of recruits, a growing sentiment in favor of temperance in the social class from which the soldier is drawn, greater effort on the part of the authorities for the early elimination of inebriates from the military service, and, finally and of the most importance, from the establishment of canteens, the favorable influence of which is subsequently discussed. The following table shows the prevalence of alcoholism in the military forces of the United States during the twenty-eight years of peace, 1870–97, inclusive.

Year.	Mean strength.	Number of cases admitted to hospital, per 1,000 strength.	Number of cases of delirium tremens, per 1,000 strength.	Year.	Mean strength.	Number of cases admitted to hospital, per 1,000 strength.	Number of cases of delirium tremens, per 1,000 strength.
1870.....	31,831	38.20	No figures available.	1884....	24,034	62.10	*
1871.....	29,430	45.80		1885....	24,138	53.50	1.57
1872.....	26,844	47.50		1886....	23,572	42.80	1.01
1873.....	27,909	49.40		1887....	23,841	46.70	.88
1874.....	27,021	58.10		1888....	24,726	40.20	.92
1875.....	23,575	68.00		1889....	25,008	41.40	.51
1876.....	24,886	64.50		1890....	24,234	40.70	.86
1877.....	23,707	59.00		1891....	23,269	40.00	.90
1878.....	23,381	59.40		1892....	24,203	37.20	.78
1879.....	23,964	65.10		1893....	25,287	33.80	.55
1880.....	24,004	61.00		1894....	25,376	30.90	.82
1881.....	23,222	57.60		1895....	25,204	30.10	.83
1882.....	23,239	68.70		1896...	25,119	28.80	.39
1883.....	23,439	66.00		1897....	25,417	27.80	.58

* No figures available.

In 1898, during the war with Spain, the admission rate fell to 15.1; the more active operations and novelty supplying much of the desired excitement, while the unusual conditions undoubtedly attracted a superior class of young men to the colors. The same was true in 1899, when the rate for alcoholism in the bulk of our army, engaged in hostilities and hard field service in the Philippines, was only about half as high as among the troops on the home stations, one-fourth as high as among those serving in Cuba and one-eighth as high as among those in garrison in Porto Rico.

ADMISSIONS FOR ALCOHOLISM AND ITS RESULTS, PER 1,000 OF EACH CLASS, 1885–97, AMONG WHITE AND COLORED TROOPS.

Year.	White troops.	Colored troops.	Average for whole army.	Year.	White troops.	Colored troops.	Average for whole army.
1885.....	59.00	4.00	54.00	1893.....	37.23	7.47	33.97*
1886.....	50.21	4.67	47.09	1894.....	33.79	4.79	30.94*
1887.....	50.88	2.23	46.31	1895.....	32.16	6.47	30.11
1888.....	43.97	4.55	40.12	1896.....	31.20	5.70	29.06
1889.....	45.64	2.07	41.43	1897.....	30.02	4.62	27.86
1890.....	44.45	5.59	40.73				
1891.....	44.19	3.39	40.01	Decade.			
1892.....	41.19	8.35	37.23*	1886–95..	42.37	4.89	38.69*

* Including Indian soldiers.

The remarkable difference existing between the white and black troops of the United States service, as regards the prevalence of inebriety, is well illustrated in the above table, statistics for extended periods showing that there is approximately only one-tenth as much sickness from the use of

alcohol among the negro as the white troops. Few colored soldiers are hard drinkers—and, as far as beer and other malt liquors are concerned, there apparently exists a racial distaste for these beverages on the part of the negro. It is a matter of frequent observation that where colored troops replace white soldiers in a garrison, the canteen profits from beer and wine are greatly diminished, while the sales of cigars and confectionery are proportionately increased.

This racial difference as regards the use of alcoholics is further shown by statistics for the British army, covering the European and non-European troops in the West Indies. During the year 1897, the admission rate for alcoholism, per thousand strength, was 15.6 for the former class, while the death rate was .74; for the native (negro) troops, during the same year, the admission rate was only .6, while the death rate from this cause was *nil.*

Among white soldiers, nationality appears to be a factor of much importance in determining the relative amount of alcoholism. Thus for the seven-year period 1890–96, the rates of admission in our army, per thousand of each class, were as follows:

Nativity.	Admissions.
American-born	28.51
German	26.62
English	51.84
Irish	90.96

For the same seven-year period, the number of admissions for alcoholism, per thousand strength, was 46.27 for the artillery branch of the service, 45.30 in the infantry and but 19.72 in the cavalry. The lower rates for the last-named service are probably due to some extent to its more active duties, but chiefly to the fact that the negro troops at that time constituted one-fifth of the cavalry force and less than one-twelfth of the infantry.

Alcoholism furnishes the single exception to the general rule that disease of any character is much more liable to attack the young recruit than the old soldier; the rate for alcoholism steadily increasing with age, where that for venereal disease, for instance, as steadily diminishes. Figures showing the influence of age upon the frequency of alcoholism, for the seven-year period 1890–96, are as follows:

Age.	Admissions per 1,000 of each class.	Deaths per 1,000 of each class.	Age.	Admissions per 1,000 of each class.	Deaths per 1,000 of each class.
19 and under..	2.87	....	35–39 inclusive	62.29	0.25
20–24 inclusive	9.17	0.02	40–44 "	104.05	.73
25–29 "	22.35	.05	45–49 "	102.91	1.51
30–34 "	42.45	.20	50–54 "	135.57	1.83

That alcoholism should be less common among our young soldiers, however, is only what should be expected. In civil life, the use of alcohol increases with age, and inebriety is most common among the middle-aged and the old. The development of drinking habits, from the tendency toward the use of alcoholics which may be possessed by the recruit, is naturally slow, and their ill effects are not usually manifested until such habits have

been established for some time. Further, as already shown, the standard of morality as regards the use of alcoholics is now much higher than it was a number of years ago, when the old soldiers, who now furnish such extremely high rates of admissions and deaths from alcoholism, were enlisted and received their first impressions in this respect.

As to the amount of drunkenness existing in foreign services as compared with our own, no exact figures can be given—for the reason that milder cases do not appear on their hospital records, but are treated in quarters or infirmary. Comparisons in this respect, however, are not favorable to our own troops. The rates are, however, relatively high in England and Germany—much lower among the Latin nations, who are comparatively free from the vice of drunkenness. In France, where absinthe is largely consumed, the rates for alcoholism are said by Laveran to be only about one-tenth as high as in the English service; and Viry states, that for the sixteen years 1875–90, the deaths from the use of alcohol in the French army amounted only to 11.5 in actual numbers annually—a considerable proportion of these occurring in Algeria. In Italy and Spain, the rates are even lower than in France—and during the occupation of territory by our troops as a result of the late war, it was a matter of common comment that an intoxicated Spanish soldier was rarely, if ever, seen. In both the British and French services, the amount of alcoholism is much greater among troops serving in the colonies than among those at the home stations.

Results of Alcoholism.—The effects of alcohol upon the organism are numerous and varied. The mental symptoms are seen in delirium tremens, epileptiform convulsions, insomnia and sensory disorders. There are congestions of the alimentary tract, sometimes causing hemorrhage, the liver is speedily disturbed and the continued use of spirits results in its congestion and ultimately in the increase of connective tissue, as seen in cirrhosis. In the military service, however, whiskey-drinkers generally break down from other causes before a marked cirrhotic condition is reached. Gastric catarrh is set up by spirits, imperfect digestion follows their excessive use, the nerve cells are changed and atrophied, the cardiac action is habitually hurried and often arhythmic, the heart muscle undergoes fatty degeneration and the arteries become atheromatous. The effect of moderate drinking, in the production of an increased amount of sickness other than that directly attributable to alcoholism, is well illustrated by the data collected by Carpenter relative to British soldiers serving in India, based upon 17,354 moderate drinkers and 9,340 abstainers. Of the former class, he found that one out of every 7.28 soldiers was admitted to hospital, where of the latter group but one out of every 14.47 was so admitted. Still more favorable to the abstinence class were the figures obtained by him for the average number of days spent in hospital; the moderate drinkers losing 102 days where the abstainers lost but 36.4 days during the same period. In another comparison, it is stated that the admissions to military hospitals in India, during the year 1891, amounted to 5 per cent. for abstainers and 10.4 per cent. for all others. Madden states that in three benefit associations in England, 1884–88, there were lost by each laborer 26.20, 24.68 and 27.66 weeks through illness—an average of 26.18 weeks —while during the same period the "Sons of Temperance," a society which admits total abstainers only to membership, showed the average number of

weeks lost by each member to be 7.48; a loss of time less than one-third that given in the other associations.

As to the actual effect of alcohol upon the death rate, it is obvious that military statistics furnish imperfect information in this respect, since only acute cases of intoxication are noted on the records. Chronic alcoholism, however, while it practically does not appear as a factor in military statistics, imparts a peculiarly grave character to all diseases occurring in drunkards, and does much, through the organic changes, local congestions and nervous depression which result from the continued use of spirits, to bring about a fatal termination in any serious affection. According to Schmidt, in the fifteen largest cities of Switzerland, where the causes of deaths are recorded by physicians without the names of the deceased being divulged, of all males twenty years of age or over, dying in 1891, alcohol figured as the immediate or remote cause of death in 10.7 per cent., and in 1892, in 10.8 per cent. With regard to the use of alcohol upon marching troops, Rosse says: "The experience of the Ashantee War, in 1876, shows that alcoholic drinks are hurtful. The men who did not touch the supplementary ration of rum presented a mortality and morbidity inferior to the other soldiers." This statement will be supported by all who have served with troops on campaign.

Drunkenness is one of the most frequent causes of insanity and suicide in the military service. In civil life, some writers attribute two-thirds of all mental diseases to alcohol, and it is said to be the chief cause of self-destruction in England, Germany and Russia. According to Madden, in the years 1878 and 1879, it was found that in 27 per cent. of all male lunatics in the asylums of Germany the existing mental derangement could be traced directly to the abuse of alcoholics. In Austria, according to Gauster, 40 per cent. of insanity occurring in males could be ascribed to alcoholic excesses. In the military service of our own country, no figures as to the influence of inebriety upon insanity are obviously available; but for the seven years 1887–93, out of 134 suicides occurring during that period, alcoholism was officially reported as being the direct cause in 31.3 per cent.

With regard to the effect of alcohol upon the performance of work, Frey draws the following conclusions: "Alcohol has an injurious effect upon the unfatigued muscle, in that it sensibly diminishes the amount of work the muscle is capable of doing. The feeling of fatigue is abolished by alcohol, and for that reason the labor seems to be lighter." He further states that: "All the pleasant sensations of physical and mental strength brought forth by moderate doses of alcohol are deceptive, and depend upon paralysis of the critical judgment and momentary blunting of the sensation of fatigue."

The quickened circulation following the use of alcohol in small amount is accompanied by the subjective feeling of warmth. This sensation, however, is wholly deceptive and depends upon the primary relaxation of the superficial capillaries; but this very relaxed condition speedily reduces the temperature below normal, through the cooling of the blood as a result of its exposure to the atmosphere through the lungs and skin, and the stimulation of the sweat glands, with the increased loss of heat through evaporation. Further, alcohol interferes with the oxidation of fatty food and in this respect impairs the power of heat-production. Wood states that the

bodily temperature in simple intoxication may fall as much as 3° C.; the fall in temperature varying directly with the quantity of alcohol taken, and the reduction of temperature being less marked in the case of chronic alcoholics than in those less habituated to its use. Hence the individual under the influence of alcohol perishes from exposure to cold much more quickly than one who is sober.

As to the effect of drunkenness upon military morals, no argument is required to show that the infractions of discipline recurring with each pay day are largely the result of alcoholic stimulation. It was noted of the British troops in India, in 1891, that of all minor offences but 1.5 were committed by abstainers where 6.7 were committed by moderate drinkers. Smart states: "The medical and court-martial records after pay-day, in all camps where whiskey can be procured, furnish data sufficient for insistence on its exclusion as the cause of much disease and many injuries and accidental deaths." As expressed by Parkes: "When debarred from spirits and fermented liquids, men are not only better behaved, but are far more cheerful, are less irritable, and endure better the hardships and perils of war. The courage and endurance of a drunkard are always lessened; but in a degree far short of drunkenness, spirits lower, while temperance raises, the boldness and cheerfulness of spirit which a true soldier should possess. If spirits neither give strength nor sustain it against disease, are not protective against cold and wet, and aggravate rather than mitigate the effects of heat; if their use even in moderation increases crime, injures discipline and impairs hope and cheerfulness; if the severest trials of war have not been merely borne but most easily borne without them; if there is no evidence that they are protective against malaria and other diseases—then the medical officer will not be justified in sanctioning their issue, or their use, under any circumstances." And Woodhull adds: "It is not necessary to insist, from theoretical or medical grounds alone, upon the mischief that alcohol causes soldiers. The observation of any officer of experience is enough. Liquor, besides weakening men physically, tampers with their will-power, disturbs their temper, makes them less trustworthy even when sober, is at the bottom of almost every violation of discipline, and is the one agent that can convert a regular force into a mob. The absence of liquor usually means a clear guard-house. Abundant liquor means a heavy sick list, a large guard report, and a general feeling of doubt as to the command. It follows without saying that if the use of alcohol is hurtful in a personal and in a martial sense to the private soldier, who is the lowest unit in the military scale, it is very much more mischievous in its ultimate consequences when an officer, who is so potent with those beneath him, is its victim."

That there are very rare emergencies in which alcohol might possess a certain value, either to supplement an insufficient issue of food or to gain a temporary stimulus at the expense of subsequent depression, may perhaps be admitted. It is certain, however, that, under nearly all conditions of military service, alcohol in any of its forms is only mischievous to the soldier. It is of interest to note, in this connection, that alcoholics still enter into the rations of most foreign armies, either as a daily or an occasional issue. Thus brandy is issued to the German troops during war; rum to the English; rum or brandy to the French; brandy or wine to the

Portuguese and Spanish; wine to the Italian, and brandy to the Austrian and Russian soldiers.

Prophylaxis.—Every effort should be made by officers for the prevention or diminution of drunkenness among troops. The dangers of the use of liquors should be fully explained to the men; and while admitting that the soldier possesses the moral right to use alcoholics in moderation should he so desire, he should, at the same time, be made to understand that on passing the bounds of intoxication he becomes a proper subject for military discipline. Offences against sobriety, if in any way capable of interfering with the performance of duty, should be uniformly and severely punished; and advantage should be taken of existing regulations to eliminate confirmed inebriates from the service as soon as possible. Company and commanding officers and court-martials should co-operate to this end. Troops are thus freed from the harmful influence of these men, and their summary punishment furnishes an example by which others will assuredly profit. Every attempt should be made to arouse a wholesome sentiment on the part of the more steady men against the inebriates, and special care should be taken to impress the former class with the fact that the penalties imposed for alcoholic excess are largely for their own protection, since they are the ones upon whom the execution of the unperformed duties of the delinquents must devolve. The better men should be made to understand that the drunkard, far from being an object of pity or worthy of consideration, is an encumbrance upon the military community of which they endeavor to form a worthy part and for whose derelictions they are thus the chief sufferers. Where such self-interest can be aroused, drunkenness is soon looked upon by the men as a vice rather than a failing—the inebriate will not be shielded by his fellows or his offence condoned.

In reducing the proportion of alcoholism among troops—aside from the summary discharge from the service of all confirmed inebriates, as above mentioned—no soldier should be re-enlisted who has shown an undue fondness for strong drink, and no discharge should be given him in which this defect is not plainly set forth. Acquaintance with military duties does not compensate for the pernicious effects, direct or indirect, produced by the drunkenness of old soldiers. A most potent factor in reducing the rates for alcoholism would be the exercise of greater care on the part of recruiting officers in refusing to accept any man as a recruit who has the slightest appearance of being addicted to the use of intoxicants. Experience has shown that recruiting officers are generally inclined to be too lenient in this respect. Much can be done to prevent alcoholic excesses through the proper administration of the canteen, and by the provision of suitable and sufficient employment and recreation; since, as already stated, a large proportion of drunkenness is the result of *ennui*. So far as the offending individuals themselves are concerned, the invariable treatment of acute alcoholism in the manner required for narcotic poisoning—by emesis, catharsis, cold douches and through lavage of the stomach—will do much to bring about the desired reform. Repetition of this unpleasant but effective treatment will rarely be necessary.

In determining the occurrence of alcoholism among troops, the example set by officers, in this respect, is of great importance. Nothing is more certain than that a drunken captain will have a drunken company.

The Canteen System.—No discussion of alcoholism among soldiers would be complete without reference to the canteen, which, more than any other factor, has operated to the welfare of troops and the promotion of temperance. This institution, officially known as the post exchange, had its origin in our service at Vancouver Barracks in 1880, but it was not until February, 1889, that it was officially recognized by the War Department and rules and regulations for its establishment and government were published to the army.

The purpose of the canteen, as officially announced, is to supply troops with goods at a low rate of profit and to afford rational recreation and amusement to all enlisted men. The sale of ardent spirits is strictly prohibited therein; but commanding officers are authorized to permit light beer and wine to be sold by the drink, on week-days, in a room set apart for the purpose, when in their opinion such action is promotive of temperance. Gambling of any character is forbidden. Each canteen is managed by an officer selected by the post commander for his fitness for the position, he being allowed one or more enlisted men as assistants; under recent orders, civilians only being allowed to serve as bar-keepers. As showing the favor with which the canteen system was received by troops, it is only necessary to say that, in 1894, five years after its inauguration, there were seventy-five canteens in successful operation in our service, and that during that year the total receipts were $1,417,079.62; of which sum no less than $304,649.91 were returned to the men as dividend profits, or about one dollar per month per man. During the year ending June 30th, 1898, the aggregate receipts of the exchanges in operation in the army amounted to $1,621,398.67, and there was received as money on deposit $189,-258.81; making the total amount of money received $1,810,657.48. There was expended for merchandise purchased, rent, fixtures and repairs, and expenses of operation, $1,297,737.16—which, less deposits, gave a profit of $323,661.51. From this amount, donations to the funds of the several regimental bands aggregated the sum of $9,154.51; to the maintenance of post gardens, $1,559.17; to post libraries, $640.06; to gymnasia, $2,-913.75; as prizes for the encouragement of athletic sports, $3,336.41, and, after setting aside the sum of $60,877.58 as a reserve fund to meet the anticipated expenses for at least one month, the sum of $254,890.93 was returned to the members in the form of dividends.

The effect of the introduction of the canteen system upon sick rates with respect to alcoholism, as shown by the reports of the surgeon-general, was prompt and marked. For the decade 1878–87, the average number of admissions for alcoholism and its direct results amounted to 64.28 per thousand of white troops. This rate diminished during the next ten years, in proportion as canteens were gradually established at various posts, omitting fractions, in the following ratio: 44, 46, 44, 44, 41, 37, 34, 32, 31, 30. On observing the admissions for alcoholism for the seven years 1885–91, which immediately preceded the general establishment of the canteen system upon a satisfactory basis throughout the army, it is found that a yearly average of 1214.8 men found it necessary to apply for treatment from this cause; while for the six years 1892–97, after canteens had been generally established throughout the army, an average of only 928.4 men required medical care as the result of alcoholism—a reduction

amounting to 23.6 per cent. In 1890, there were 17 posts at which the admission rate for alcoholism exceeded 10 per cent. of the strength. In 1891, the number of such posts had decreased to 11, and in the six subsequent years diminished at the following rate: 10, 7, 4, 5, 2, 2. This favorable showing for the army at large was duplicated in the case of each individual post; the introduction of the canteen, at a military station, in no instance failing to be promptly followed by a diminution of alcoholism. For certain stations this improvement was extraordinary. In 1889, Willet's Point had an admission rate for alcoholism of 222.97 per thousand. For 1890, the year during which the canteen was established at that post, it fell to 157.50, and in the next year was reduced to only 70.46. At Fort Spokane, the amount of sickness resulting from intoxicants was reported by the surgeon as having diminished fifty per cent. during the six months following the institution of the canteen. At Fort Douglas, in 1888 and 1889, the total number of admissions attributed to alcoholism amounted to about 85 per thousand strength; while during the period 1892–94 this rate fell to 52.95 per thousand strength—and such instances might be largely multiplied.

All are agreed as to the value of the canteen in the tropics, as well as at home stations, in reducing alcoholism. A report by O'Reilly upon the condition of the British troops in Jamaica, states that the canteen, from which the men can always procure beer, has been largely instrumental in the disuse of stronger spirituous liquors and in a lessening of the evils which followed the free use of spirits in the tropics. In referring to the condition of the Fourteenth United States Infantry at Manila, Cardwell expresses his belief that a great improvement shown in the figures for venereal and alcoholism in this regiment was due to the establishment of a canteen, kept under admirable discipline, and he adds: "Cool American beer as a substitute for the 'beno' of the native gin-shops has a most beneficent effect." From Porto Rico, the report of the inspector-general is as follows: "The post exchanges of this department have been the means of elevating the enlisted men by keeping them away from low and cheap resorts and the worst elements of Porto Rican society. I have noted that the exchange as operated in the department has reduced instead of increasing drunkenness, and by the profit of operation, which is divided among the enlisted men, has greatly increased and improved the messing of the soldiers—thereby his happiness and health—by providing him necessities and luxuries not otherwise obtainable." Reports of this character could be multiplied almost indefinitely; the views of nine-tenths of the officers and men, nearly a thousand in number, whose opinions on the canteen were officially asked by the War Department, in 1899, being favorable to the institution as at present operated.

The cases of delirium tremens will be accepted by all as furnishing reliable data by which the gravity of the admissions for alcoholism may be determined. It is therefore of interest to observe that for the seven-year period above noted, prior to the complete adoption of the canteen system, the average annual admissions for this cause, actual numbers, was 23.8; while for the six-year period following the general establishment of this system the average number of men admitted yearly for delirium tremens was 16.6—a reduction of 31.3 per cent. in this serious class of cases. It can

scarcely be doubted that this remarkable decrease was chiefly influenced by the general substitution of beer—a milder beverage, which rarely produces delirium tremens—for distilled liquors, the free use of which is well known to result in great mental excitement and nervous exhaustion.

It is recognized that alcoholism and insanity are closely related through the direct influence exerted by intoxicants in the production of mental aberration. Hence it is not surprising to find that the average number of cases of insanity, annually coming under treatment, was 35.1 for the seven-year period, 1885–91, prior to the complete establishment of the canteen system, and only 24 as an annual average for the six subsequent years, 1892–97. These figures show a reduction in insanity amounting to 31.7 per cent. As to the number of days of service lost annually from insanity, the improvement since the institution of the canteen is even more marked. Figures for the years 1885 and 1886 are not available; but for the five-year period 1887–91 the average number of days lost was 1,563, while for the six years 1892–97 the service annually lost to the Government from this cause amounted to only 924.5 days—a decrease of 40.9 per cent.

The canteen, for the maintenance of good order in which a commissioned officer is held responsible, is an aid to discipline as well as to the health and morals of troops. It provides a resort which, while under thorough military control, offers inducements to the men to remain at home and spend their idle time within the limits of the post; this condition obviously being far preferable to the one formerly existing when the nearest and generally patronized places of amusement and refreshment were the grog-shops, usually with gambling-room and brothel annexes, which marked the limits of each military reservation. Except with the most dissolute class of men, the soldier is well satisfied to patronize the canteen to the exclusion of outside saloons; knowing, as he does, that he receives good value for his money in articles of excellent quality, and fully appreciating that the profits of the institution ultimately accrue entirely to his benefit, and are not, as with the case of outside establishments, diverted to the advantage of others. Besides the congenial resort which it furnishes, the influence of the profits of the canteen in promoting contentment among troops can scarcely be overestimated; contributing, as they do, to improvement of the food, the attainment of wholesome amusement and the provision of much by which the soldier's life is made less irksome, and he himself rendered more efficient in the performance of his military duties.

Year.	Average strength.	Deserted.	Per cent. of desertions.	Year.	Average strength.	Deserted.	Per cent. of desertions.
1885	24,816	2,626	10.6	1892	24,869	1,410	5.7
1886	24,365	2,012	8.3	1893	25,670	1,632	6.3
1887	24,438	2,525	10	1894	25,661	926	3.6
1888	24,790	2,678	11	1895	25,209	1,341	5.3
1889	25,564	2,730	11	1896	25,143	858	3.4
1890	24,930	1,922	7.7	1897	25,300	726	2.9
1891	24,525	1,398	5.7				
Average for seven years before canteen system was thoroughly established			9.18	Average for six years after canteen system was thoroughly established			4.53

The best index of the contentment of troops is to be found in the rate of

desertions, since it is obvious that the soldier who is well satisfied with his lot will not endeavor to escape from the performance of his military obligations. That the canteen system has, from this standpoint, operated to the general welfare of the men is undoubted; the desertions and percentage of desertions in the regular army, from 1885 to 1897 inclusive, being as given in the previous table.

From the above table, it is observed that during the first year after the canteen system was officially established the rate of desertions fell 30 per cent., while in the next year the rate was further reduced to 48 per cent. For the five years previous to the establishment of the first officially recognized canteen, the number of men annually deserting from the service, per thousand strength, amounted to 101; while for the eight years immediately subsequent to the institution of this system the annual number of desertions was reduced to 50 per thousand strength. The decrease noted has been practically progressive—and it will be seen that for the two years immediately prior to the war with Spain scarcely one-fourth the number of men, as compared with the average for the three years immediately prior to the introduction of the canteen system, found the military service so uncongenial as to desire to escape from completing their terms of enlistment. These results are certainly most gratifying, and there is no reason for believing that, with the development of the canteen along its legitimate lines of growth, a still further decrease in the present small rate of desertions may not be confidently anticipated.

Drunkenness is certainly prevented by the constant military supervision to which the canteen is subjected. The men themselves are usually careful not to indulge in alcoholics to the point of inebriety; while such few individuals as are inclined to be forgetful of the dangers of excess will usually be restrained by companions, or by those connected with the establishment —who have no personal interest in promoting the sale of liquor, as does the saloon-keeper of civil life—from passing the bounds of actual intoxication. When such a condition has actually resulted, the drunken individual will rarely be left to his own devices or permitted to become offensive, and is usually prevailed upon by others to return to barracks without committing any breach of discipline. Hence brawls and disturbances—with resulting court-martial—have, since the introduction of the canteen system, become relatively infrequent, and pay-day, formerly synonymous with debauchery and riotous disturbance, is now scarcely to be distinguished by its effects from any other day. As illustrating the marked reduction of convictions for drunkenness or complications arising therefrom, since the establishment of the canteen system, the following figures given on the following page, from the reports of the judge-advocate-general, are of interest.

From these figures it is evident that, coincident with the general establishment of the canteen system throughout the army, there has occurred a decrease amounting to considerably more than one-half the drunkenness which formerly tended to the impairment of discipline, the demoralization of individuals and to the occurrence of assaults, injuries and deaths. It is idle to deny that this excellent result has not been largely due to the attraction furnished by the canteen, combined with the military discipline which prevails in that institution and which reduces to a minimum the possibility of dangerous excesses.

Year.	Total number of trials and convictions in the army. All causes.	Number of trials and convictions for drunkenness and conditions arising therefrom.	Year.	Total number of trials and convictions in the army. All causes.	Number of trials and convictions for drunkenness and conditions arising therefrom.
1886.....	1,640	342	1894.....	1,728	120
1887.....	1,730	289	1895.....	1,486	142
1888.....	1,999	357	1896.....	1,384	168
1889.....	1,752	423	1897.....	1,245	143
1890.....	1,907	407	Average for six years 1886–91.	1,838	372.5
1891.....	2,000	417			
1892.....	2,198	228	Average for six years 1892–97.	1,605	160.6
1893.....	2,189	163			

The influence of the canteen in promoting order and contentment is less directly, though none the less positively, shown by the number of soldiers making savings-deposits with army paymasters. For the above periods, the figures given in the report of the paymaster-general for 1899 show that the average number of men annually making such deposits, for the seven years 1885–91, was 7,273; while for the six years 1892–97 the annual average so depositing was 8,382—an increase of 13.3 per cent. Such an increase can be interpreted only as meaning that a larger number of men found the service so congenial that they purposed to serve their entire enlistment without the thought of a possible desertion with its forfeiture of deposits. Also that a greater proportion of soldiers found that their pay, with the greater value given by the canteen in return for their money, was in excess of their immediate needs; and further, that the restriction of gambling—brought about by its prohibition in the canteen and the lessened frequenting by the men of resorts in which gaming, often of a dishonest character, was a prominent attraction—kept the money distributed among the many and prevented its accumulation by the few or its loss to outsiders. It may be also that the constant example set by the canteen as a successful co-operative institution was not without its effects in promoting soberness and steady business habits throughout the command. A saving class of men is naturally a law-abiding class, and it cannot be denied that the average annual increase for the latter period mentioned above, of 1,109 men who had practically placed themselves under bonds to the Government for their good behavior and continuance in the service, was not without a powerful influence in raising the morale of the troops and promoting their efficiency. That this, indeed, was actually the case is demonstrated by the figures relating to desertions and court-martials already given.

The opportunity given the men of purchasing light, nutritious lunches in the canteen is certainly of much benefit. Many articles of food not obtainable in the company mess are thus brought within reach, and the monotony which often pertains to company cookery may in this manner be agreeably interrupted. It is probable, too, that this feature does much to prevent the intemperate use of alcoholics. The gastric cravings of hearty and idle men are thus satisfied, and a sandwich with the glass of beer largely decreases the desire for an additional quantity of the latter.

It is claimed by the advocates of total abstinence that by the sale of beer in the canteen the health and morals of the soldiers are impaired;

that such tacit encouragement on the part of the Government favors indulgence in alcoholics and that drinking habits are thus formed by those who might otherwise have remained sober men. These objections are purely theoretical and are at variance with facts as observed since the establishment of the canteen. The sale of beer, under suitable restrictions, undoubtedly results in good rather than evil to the troops at large, and may justly be looked upon as a safety-valve for those accustomed to regard the use of a certain amount of liquor as both harmless and proper. Comparatively few men to-day become inebriates from a taste for alcohol acquired in the military service; and where certain individuals may imbibe too much beer on pay-day, they constitute a class which, in the absence of a mild beverage of this character, would probably resort to stronger liquors—frequently sophisticated—outside the limits of the command. That beer-drinking, viewed in the abstract, is unproductive of good will be admitted by all; that when properly controlled, its sale in canteens, rather than its prohibition, redounds to the general health, morals and military efficiency, few, if any, who are conversant with the subject would attempt to deny. It is certainly unfortunate that the temperance element in civil life which is so constantly endeavoring to enact legislation against the sale, in the military service, of alcoholics of any character, cannot be brought to regard the matter from the practical rather than the sentimental aspect and thus assist in controlling and largely curtailing an evil which it is powerless to prevent, and which, if its efforts toward restrictive legislation should be successful, would undoubtedly be greatly increased. At present its efforts toward the abolition of the canteen merely oppose theory to facts and sentiment to statistics.

It may here be remarked that the view is commonly entertained, by the civil class just mentioned, that the soldier is peculiarly dissipated above all others and requires special legislative measures to safeguard him against his weakness; the fact being wholly ignored that the army is recruited from the general community and merely reflects the qualities of the latter, whether they be good or bad. The recruit brings with him into the service the result of the moral moulding to which he has been subjected during childhood and youth in civil life, and does not change his nature or moral standards with the mere donning of the uniform. The vice of drunkenness is certainly neither initiated nor aggravated as a result of military service, and, if the opinions held by some outsiders are correct as to the moral conditions obtaining in the army, then the cause must be sought for within the social classes and the conditions of environment from which the human material composing the army is drawn. It is certain that no more drunkenness has existed in the army during the past few years than occurred in the corresponding classes of civil life—if indeed there was not less.

As already stated, it is intended that the canteen should provide a place in which the rational and profitable occupation of leisure time may be encouraged; and it is obvious that this object is not attained by the mere establishment of a bar. The canteen should be fitted up like a club, and should possess, in addition to the bar and lunch features, facilities for billiards, card and game-rooms, reading-room and library. If the beer-selling feature of the canteen is given undue prominence, the better and

essential character of the resort suffers. Hence the bar should merely be an adjunct and not constitute, as is sometimes the case, the most important part of the institution. No alcoholics should be sold until two hours after the men have breakfasted, to avoid the possibility of early morning tippling and the greater danger resulting from the use of alcohol on an empty stomach. Seats and tables in sufficient number should be provided, and drinking at the bar discouraged. The present regulations forbidding the practice of treating should be strictly enforced. In the British service, at certain stations, it is customary to limit the amount of beer sold to each man—usually to about three pints daily—and this practice might with advantage at certain times be adopted in our own service. With men of known tendency toward inebriety, either the quantity of alcoholics with which they may be furnished should be carefully defined, or they might be entirely debarred from purchasing beverages of this character. Any possible ill effects from the sale of light wines and beer would be largely prevented by the supply, gratis, of a certain amount of cheap but nutritious food—not of a thirst-producing character—to all purchasers of alcoholics. The use of credit, at stated periods and in limited quantities at posts where more restrictive measures are not in vogue, would be of benefit as affording less opportunity for excess at any one time. On the other hand, so much credit should not be allowed that the soldier would find his entire resources swallowed up in his indebtedness, and thus become discontented.

The canteen should close at a comparatively early hour, so that insufficient rest on the part of the soldier, whose day begins early, need not be chargeable against it. Undesirable characters, civilians of either sex, should be excluded from the canteen; and every care taken to observe all sanitary precautions and maintain due cleanliness. Eating and drinking at all other places in the vicinity of the camp or garrison should be discouraged, since it is undoubtedly the case that infectious diseases are often dispersed through the uncleanly methods of irresponsible venders of articles of food, alcoholics and temperance drinks. Particularly is this the case in the relation of water-borne diseases to non-alcoholic beverages—to which class of drinks many outbreaks of cholera and typhoid fever have been justly attributed. Coffee should be kept on hand and sold at cost rates. In the tropics, the establishment of aërated-water machines in connection with the canteen would often be of advantage; waters of this character being both wholesome, cheap and popular.

At present there is a strong tendency by some officers to utilize the canteen—and stimulate the sale of beer—solely as a means of increasing the company funds. This should be strongly opposed, and the profits of the institution regarded as the happy result rather than the cause of its existence. It would be much to the advantage of troops if the allotment to company funds was officially limited to fifty per cent. of the profits; twenty-five per cent. being expended to further athletic sports and amusements among the men and the remainder to be reserved as a contingent fund for fixtures, improvements, insurance and similar purposes.

In general, the regulations for the government of the canteen, while rational and comprehensive, should not be too severe, lest the popularity and hence the value of the resort be impaired. This point requires the exercise of much discretion. It should be understood that the institution,

while naturally a great benefit, may become a positive evil to troops if the officer in charge is remiss in his obligations, indifferent or incompetent.

Temperance Clubs.—In the British service in India, an attempt is being made to diminish drunkenness among troops by the substitution of coffee-houses for the canteen. While libraries, recreation rooms, workshops, gardens and cricket-grounds had been established for many years, it was not until 1887 that a further development was made by bringing together the regimental and company clubs and forming them into what is now known as the "regimental institute." The aim and object of these "institutes" are to improve the social condition of the soldier and to reduce intemperance by the provision of such reasonable comfort and physical as well as mental recreation as to make them a center of attraction and lessen the habit of seeking entertainment elsewhere. This plan has now been put into operation in nearly every regiment in India. As to its effects, it was reported by Lord Roberts, in 1890, that an improvement following its introduction was apparent, as was shown by the following figures for the troops in Bengal:

	1888.	1889.	Decrease.
Total number of men punished, per cent	2.34	2.01	0.33
Number of cases of insubordination with violence	307	257	50
Number of cases of drunkenness tried by court-martial	149	98	51
Number of men sentenced to imprisonment with hard labor	957	781	176
Number of men discharged with ignominy	110	79	31

In the Bombay forces, the results are equally satisfactory—but the conditions were reversed with troops in the Madras Presidency. Put in the most appreciable form, the following figures give all the convictions by court-martial, as compared with the preceding year: In Bengal the number of courts-martial decreased by 14.11 per cent. In Madras the number of courts-martial increased by 1.22 per cent. In Bombay the number of court-martials decreased by 17.29 per cent.

Should the total-abstinence element of the country succeed in abolishing the canteen, as at present existing, it would seem as if the establishment of such a central recreation-room and temperance club would be advisable; although that such an institution can take the place of the canteen, in the promotion of temperance among the large class of soldiers who enjoy an occasional glass of beer, cannot for a moment be admitted. Such men would seek their beer outside the limits of the reservation, in the resorts which would spring up like mushrooms were the canteen abolished. There can be no doubt that the aggregation of a number of means of amusement under one roof does much to increase the individual value of each.

VENEREAL DISEASE.

Occurrence.—Of all the causes by which the soldier is brought in sick-report, in time of peace, venereal disease is of the most importance and affects his efficiency to the greatest extent; this being particularly the case in our own service as compared with most foreign armies.

The following table shows the ratio of admissions, per 1,000 strength, for all forms of venereal disease in the principal armies of the world, largely compiled from official figures furnished the commission lately investigating the prevalence of venereal affections in the British army.

Year.	France.	Germany.	Austria-Hungary.	Russia.	Italy.	Holland. Home stations.	Japan.	United States.	Great Britain.	
									Home stations.	India stations.
1872	....	....	62	....	....	...	....	109.3	202.2	191.0
1873	....	....	56	....	....	....	....	101.7	167.6	181.6
1874	....	38.4*	53	....	....	....	....	92.5	145.7	207.5
1875	....	31.6	59	....	....	....	....	110.4	139.4	213.5
1876	57	28.8	65.8	....	....	....	....	107.6	146.5	203.5
1877	57.8	30	66.9	....	....	....	....	97.7	153.2	224.4
1878	59.7	36	75.4†	....	....	....	....	97.8	175.5	291.6
1879	63.7	38.5	81.4	....	....	....	....	95.1	179.5	253.3
1880	65.8	34.9	75.7	....	....	....	....	96.7	245.9	249
1881	60.6	39.2	79	....	....	....	....	91.8	245.5	259.6
1882	62	41	73.7	....	....	....	....	78.4	246	265.5
1883	58.9	38.2	73.3	....	....	....	....	76.6	260	271.3
1884	52.1	34.5	73.5	....	....	....	....	75	270.7	293.5
1885	50.7	32.6	69	....	....	....	....	79.6	275.4	342.6
1886	49.6	29.7	65.8	....	....	....	....	71.9	267.1	385.8
1887	51.6	28.6	64.4	....	47.5	....	39.3	74.37	252.9	361.4
1888	46.7	26.3	65.4	42.4	76.5‡	....	29.7	80.88	224.5	372.2
1889	45.8	26.7	65.3	40.7	66.6	....	24.7	84.66	212.1	481.5
1890	43.8	26.7	65.4	43	73.4	96	27.3	75.22	212.4	503.6
1891	43.7	27.2	63.7	41.5	71.5	60.4	37.5	72.46	197.4	400.7
1892	44	27.9	61.6	44.6	69	53.1	36	76.73	201.2	409.9
1893	42.8	....	64.5	43.1	93.3	45.8	....	73.08	194.6	466
1894	40.9	....	64.8	39.5	92	54.3	....	80.4	182.4	511.4
1895	....	...	61	36	84.8	48.1	....	73.7	173.8	522.3

* In the case of Germany, 1873–74, 1874–75, and so on.
† Bosnia and Herzegovina were occupied in this year.
‡ Compulsory examination of prostitutes abandoned.

Among European armies, that of Germany has by far the lowest rate for venereal disease. Russia and France come next, then Austria-Hungary, then the troops of Holland serving at the home stations, then Italy. No army included in the above comparison, except that of Great Britain, has as high a rate as that shown for the United States forces; and with us, moreover, the actual prevalence of venereal disease is probably greater than the returns indicate, through the concealment and self-treatment so often practiced by the men in the milder cases, by the use of patent medicines. The small amount of disease of this character in the army of Japan is noticeable. In all the above armies, with the exception of those of Great Britain and the United States, some special regulations are in force for preventing the spread of venereal affections. These generally consist of weekly or fortnightly examinations of the men for the detection of venereal disease—non-commissioned officers and married men being in some cases exempted—and registration and periodical examination of all women ascertained to be leading a life of prostitution, with compulsory isolation of such as are found to be diseased. In the Italian army, regulations of this latter kind were revoked in 1888.

In the case of most of the armies mentioned above, the comparison with respect to various forms of venereal disease may be carried into further detail, as follows:

MEAN ANNUAL ADMISSION RATE, PER 1,000 STRENGTH, FOR THE THREE YEARS 1890–92.

	Germany.	France.	Russia.	Italy.	United States.	DUTCH TROOPS.		BRITISH TROOPS.	
						Home stations.	East Indies.	Home stations.	In India.
Primary and secondary syphilis.....	5.5	9	13.1	13.9	16.83	14.8	47.0	101.7	175.4
All other venereal diseases.....	21.8	34.9	29.9	57.4	57.96	55	408.6	101.9	262.6

In these years, it is apparent that the German army had scarcely more than one thirty-second, and no European army had as much as one-eleventh of the amount of syphilis as devastated the British troops in India. The Dutch troops in the East Indies, with an exceedingly high rate of venereal disease generally, did not suffer from syphilis one-third as much as did the British soldiers serving in India—where the rate has, moreover, risen rapidly since the period included in the above comparison, while in the Dutch East Indies it has materially declined. The figures with regard to syphilis show much less of this serious affection among European armies, excluding England, than exists among our own military forces.

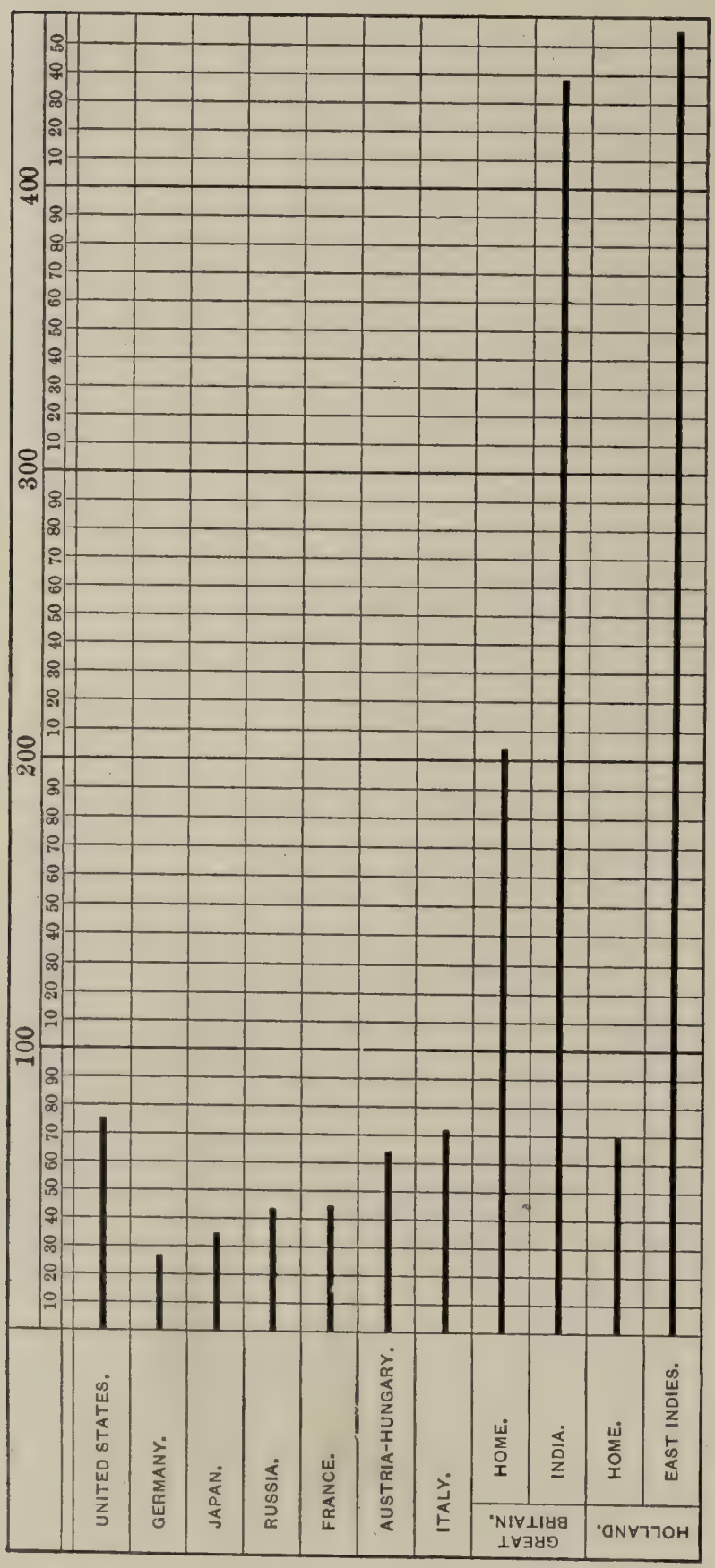


FIG. 368.—Average Annual Admissions, per Thousand Strength, for all Venereal Diseases, in the More Important Armies of the World. Based on the three years 1890, 1891 and 1892.

Among venereal diseases, syphilis is of particular importance as directly influencing the military efficiency of an army. This affection, even at its best, seriously undermines the constitution and renders the soldier at all times less resistant to invasion by acute disease and to a fatal termination. Even in such cases as are ultimately returned to duty, the men have frequently been in hospital for considerable periods and are

prone to later manifestations from a temporarily latent infection. In such instances, the state has not only paid the man for the time he was unfitted for duty but receives back a doubtfully efficient soldier, extremely liable to break down under the fatigue and privations of field service.

The prevalence of syphilis in the United States army, during thirty years of peace, is shown by the following figures:

Year.	Admissions to hospital, per 1,000 strength.	Year.	Admissions to hospital, per 1,000 strength.	Year.	Admissions to hospital, per 1,000 strength.
1868	105	1878	47.7	1888	22.2
1869	97	1879	44.3	1889	22
1870	69.4	1880	49.4	1890	19.7
1871	67.7	1881	47.6	1891	14.7
1872	60.3	1882	40.1	1892	16
1873	55.7	1883	35.6	1893	13.6
1874	47.3	1884	29.8	1894	14.1
1875	60	1885	24.8	1895	11.1
1876	59.6	1886	22.3	1896	10.9
1877	50	1887	22.9	1897	12

During the year 1898, the admissions for this disease were only 10 per thousand; in 1899, they were 14.38 for the tropical islands and 13.49 for troops serving in the United States. As is seen by the above figures, syphilis has steadily diminished since the Civil War down to the year 1898 —and to one-tenth of the amount existing in 1868. While it is probable that a certain proportion of this reduction is due to a more accurate differentiation between the hard and soft venereal sores, the gratifying fact nevertheless remains that the reduction in syphilis among our soldiers has not only been great but steadily progressive.

While in the various armies on the European continent the tendency is rather toward a reduction than an increase of syphilitic infection, in the British army at home—and particularly among the British troops in India —a serious feature of recent years has been the disproportionately great increase in the amount of primary and secondary forms of this disease. This growth was not great prior to 1884, when the Contagious Diseases act was revoked, but since that time the advance has been appalling. In the following tables, the rapid development of syphilitic disease among the British troops in India is well shown; figures for primary syphilis not being given for the period prior to 1887, as the hard chancre was not differentiated from the non-syphilitic sore until that year—and then only in part.

SECONDARY SYPHILIS.

(Ratio of admission per 1,000 strength.)

Year.	Admissions.	Year.	Admissions.	Year.	Admissions.
1872	22.4	1878	22.1	1884	24.4
1873	20.4	1879	24.1	Mean for years	
1874	25.2	1880	23	1872–84	23.3
1875	25.1	1881	23.1	1885	28.7
1876	23.9	1882	23.2	1886	33.3
1877	22.1	1883	23.5	1887	29.4

Year.	Primary syphilis.	Secondary syphilis.	Year.	Primary syphilis.	Secondary syphilis.	Year.	Primary syphilis.	Secondary syphilis.
1887.....	75.5	29.4	1890.....	135.6	66.3	1893....	129.3	61.6
1888.....	72.1	32.4	1891.....	104	60	1894....	173	74.6
1889.....	134.3	51.2	1892.....	102.6	57.8	1895....	174.1	84.9

In 1893, from the British troops in India, venereal disease of all forms caused 466 admissions per 1,000 strength. No less than 2,619 men, or more than the equivalent of two regiments, were constantly in hospital throughout the year from this cause. Each case required treatment for thirty days, and the rate for each soldier of the entire army was twelve days lost. The admissions for syphilis in all its stages were 275 per 1,000. Of 70,642 British soldiers serving in India on the 15th of July, 1894, 19,892, or 28 per cent., had been admitted to hospital for syphilis since their arrival in India. Only 26,247 men, or 37 per cent., had never suffered in or out of India from any venereal disease. Of the 13,000 soldiers who returned to England from India in 1894, over 60 per cent. are reported as having suffered from some form of venereal infection. In 1895, an average of 45 men out of every 1,000 were constantly in hospital for venereal disease. These figures, however, by no means represent the total amount of inefficiency due to this cause. Many cases of secondary syphilis, in the last few years, have been treated in the British service by hypodermatic injection of mercury, without admission to hospital, and do not, therefore, figure in the returns; while a large number of men who are nominally cured are only fit for light duty under peace conditions. Among 5,822 men detailed for field service with the Chitral relief force, 462, or nearly 8 per cent., had to be rejected for venereal disease; 279 more, or an additional 4.5 per cent., had subsequently to be transferred from the field hospitals to the base for the same cause. The report of the Departmental Committee says: "In 1895, venereal disease attacked the British troops in India to an unprecedented extent. Out of the enormous total of 522 cases of venereal per 1,000 troops, syphilis contributed nearly one-half, *i.e.*, 259 cases per 1,000; a figure many times greater than the highest of which we can find any record in the statistics of continental armies, for recent years, either at home or abroad. Venereal disease caused more than one-third the total amount of sickness, the constant disablement of 3,200 men out of a total force of 71,000 and a vast amount of partial disability and unfitness for any but routine duties." Concerning the campaign in India in 1897, it is stated that out of an actual strength of 16,600 British troops, 1,481, or nearly 7 per cent., were found to be disqualified for service through venereal disease.

It is probable that there is less syphilis among our troops than exists among the unmarried male civilians of the same class, since those soldiers who are recognized as infected are promptly discharged from the military service in nearly all instances. For the same reason, syphilis does not figure to any extent in the death rate. Among such few affected individuals as may be retained in the service, the effects of syphilitic infection are slow and insidious, and manifest themselves in unfavorably modifying other affections. Thus such affections as Bright's disease, cirrhosis of the liver and amyloid degeneration are undoubtedly largely induced by it.

Gonorrhœa, in contradiction to syphilis, has been steadily on the increase in our service for the past fifteen years; thus showing that there has been no improvement in the morals of the United States soldier as regards the maintenance of chastity. In 1885, the admission rate was 37.76 per 1,000 strength, while in 1897 the rate was 56.21 per thousand. For the year 1896, the number constantly sick from this cause in the British service was 9.15 per thousand as compared with 3.22 in the United States army for the same period. In 1890, the admissions in the French army for gonorrhœa, per 1,000 strength, were 27.9.

Causes Affecting the Prevalence of Venereal Disease.—The influence exerted by race upon the prevalence of venereal infections is not, in general, sufficiently appreciated. A marked difference in this respect exists even among the various armies of Europe, where similar measures of prophylaxis are employed; but it is when the rates for Asiatic forces are compared with those for white troops, serving under the same conditions, that the greatest difference is observed, and particularly so with reference to syphilis. It is certainly true that this disease, introduced comparatively recently among the Caucasian and negro races, commits far greater ravages among those in which it has not long prevailed, than among peoples who have presumably acquired a comparative immunity to the affection, transmitted through a syphilized ancestry extending through scores of generations. It appears to be true, also, that certain races possess in large degree peculiar powers of resistance to gonorrhœal infection, a quality long since demonstrated to exist in certain individuals of even the most susceptible peoples.

The following table, taken from the report of the commission investigating the prevalence of venereal diseases among the British troops in India, shows the great difference in the admission rates for syphilis and all venereal affections among Europeans and Asiatics, per thousand of strength.

Year.	Army in the Dutch East Indies.				Army in British India.			
	Dutch troops.		Native troops.		British Troops.		Native Troops.	
	Syphilis.	All venereal diseases.	Syphilis.	All venereal diseases.	Syphilis.	All venereal diseases.	Syphilis.	All venereal diseases.
1890	53.9	483.9	11.0	248.0	201.9	503.6	18.2	41.1
1891	43	442	11.6	243.6	164	400.7	16.3	37.9
1892	44	440.9	9.7	223.5	160.4	409.9	17.1	39.6
1893	40	370	8	218	190.9	466	17.9	36.4
1894	37	416	7.8	191.8	247.6	511.4	17.7	32.3
Mean for five years	43.6	424.7	9.6	225	195	458.3	17.4	37.5

In the Dutch East Indies, the Asiatic troops suffer from all venereal diseases but one-half as much, and from syphilis about one-fifth as much, as do the Europeans. In the British army in India, the native troops are not affected with venereal diseasee one-twelfth as much, nor from syphilis one-eleventh as much, as are the white troops. It is probable that, in India, caste feeling helps to deter the native soldier, to some extent, from

consorting with the lowest and most dangerous class of prostitutes—but his remarkable freedom from venereal infections can be satisfactorily explained only on the ground of racial insusceptibility. It is of interest to note that while the admission rate for British troops in India has more than doubled since 1881 in respect to venereal disease, among the native troops there has been no appreciable increase during this period. An inference which may be legitimately drawn from this fact is that venereal disease has not increased to any remarkable extent among the loose women of the country generally, but that among the class with whom the British soldier associates there has been an increase out of all proportion to their numbers, directly as a result of such relations—both the native women and the British soldiers presenting rates far in excess of their racial normals. As between whites and negroes, the greater resistance to venereal diseases lies with the former, probably through a longer exposure to the processes of immunization through heredity. Comparative figures for these two classes in our own service, for all venereal diseases, are as follows:

Year.	Admission rate per 1,000 strength, whites.	Admission rate per 1,000 strength, colored.	Year.	Admission rate per 1,000 strength, whites.	Admission rate per 1,000 strength, colored.
1884.....	75.00	101.00	1892.....	75.71	86.94
1885.....	80	76	1893.....	74.94	49
1886.....	No figures.	No figures.	1894.....	82.21	47.46
1887.....	72.13	95.98	1895.....	75.57	52.26
1888.....	78.08	98.51	1896.....	80.04	56.53
1889.....	84.86	82.75	1897.....	81.80	114.60
1890.....	72.02	105.39	1898.....	78.48	149.58
1891.....	70.64	80.18	1899.....	128.59	195.92

No satisfactory explanation for the sudden and marked reduction in the above admission rates for the colored troops during the period 1893–96 can be offered. The experience of the British in the West Indies shows a higher percentage of venereal infections among the colored troops than among white soldiers—syphilis being more than twice as common among the former as among the latter. This difference with respect to syphilis holds good, also, in our own service; the admission rates for the several classes of venereal disease, per thousand of each class, being as follows:

Year.	White Troops.			Colored Troops.		
	Syphilis.	Gonorrhœa.	Chancroid.	Syphilis.	Gonorrhœa.	Chancroid.
1898.....	9.39	51.18	17.91	28.44	67.29	54.05
1899.....	13.39	78.16	37.04	22.43	109.82	63.67

A second point well worthy of careful consideration is found in the fact that venereal infection, particularly that of a syphilitic nature, appears to take place more certainly, and to assume a much more severe character, when relations are entered into between individuals of different racial characteristics than when both are of the same nationality; the aliens suffering, in this respect, to a greater degree than the resident population. Troops quartered among a foreign but not hostile population almost invariably suffer worse in respect to venereal diseases than do those at home.

In the Austrian army, a large increase in affections of this character followed the occupation of Bosnia and Herzegovina in 1878; the French troops in Algeria are more affected with venereal diseases than those in France, and the same is true to a marked degree in the case of the British troops in India and that of the Dutch in Java. The proportion of venereal disease is higher among our troops outside the limits of the United States than among those serving at home stations. In speaking of the native troops stationed in Bengal, it has been said that the "Gurkhas, being foreigners, have higher rates (for venereal disease) than other native troops." These conditions, however, do not obtain when a command is moving or during campaign.

RELATIVE AMOUNT OF VENEREAL DISEASE AMONG FRENCH TROOPS IN FRANCE AND IN ALGERIA.

(Ratio of admissions, per 1,000 strength.)

Year.	FRENCH TROOPS AT HOME STATIONS.				FRENCH TROOPS IN ALGERIA.			
	Syphilis.	Chancroid.	Gonorrhœa.	Total.	Syphilis.	Chancroid.	Gonorrhœa.	Total.
1892.....	8.3	5.6	27.4	41.3	15.0	11.9	28.6	55.5
1893.....	8.4	5.8	25.3	39.5	15	12.1	32.5	60.6
1894.....	7.4	5.2	23.5	36.1	13.2	11.4	26.6	51.2

RELATIVE AMOUNT OF VENEREAL DISEASE AMONG BRITISH TROOPS AT THE HOME STATIONS AND IN INDIA.

(Admissions, per 1,000 strength, for the decade 1887–96.)

Disease.	British army at home stations.	British army in India.
Primary syphilis.....	59.2	127.5
Secondary syphilis.....	35.9	62.2
Gonorrhœa.....	86.2	176.3

RELATIVE AMOUNT OF VENEREAL DISEASE AMONG DUTCH TROOPS AT HOME AND IN THE EAST INDIES.

(Ratio of admissions, per 1,000 strength.)

Year.	AT HOME.			ABROAD.					
				Europeans.			Asiatics.		
	Syphilis.	Other venereal diseases.	Total.	Syphilis.	Other venereal diseases.	Total.	Syphilis.	Other venereal diseases.	Total.
1885.....	No return for the years.			58.9	335.0	393.9	15.7	188.0	203.7
1886.....				60	411	471	15	143	158
1887.....				61.8	447.7	509.5	16.3	221	237.3
1888.....				53	384	437	12.9	203	215.9
1889.....				49.8	417.6	467.4	12.6	254	266.6
1890.....	13	83	96	53.9	430	483.9	11	237	248
1891.....	18	42.4	60.4	43	399	442	11.6	232	243.6
1892.....	13.4	39.7	53.1	44	396.9	440.9	9.7	213.8	223.5
1893.....	10.8	35	45.8	40	330	370	8	210	218
1894.....	13.3	41	54.3	37	379	416	7.8	184	191.8

Climate also appears to influence the prevalence of venereal as well as its intensity and character; a tropical climate appearing to lower the vital

resistance as regards invasion by venereal infection, to induce an affection of unusually severe type, and, in syphilis, to cause the determination of superficial rather than deep-seated lesions. The amount of venereal disease among troops bears a close relation to the age of the soldiers; young men, and particularly young recruits, being especially liable to such diseases. This is very strikingly shown in the following table, which gives the admissions for venereal affections in our service, divided according to age, per thousand of each class, for the seven-year period 1890–96.

Age.	Syphilis.	Gonorrhœa.	All venereal diseases.	Age.	Syphilis.	Gonorrhœa.	All venereal diseases.
19 and under....	22.25	128.50	193.82	35 to 39 inclusive	8.17	10.20	24.59
20 to 24 inclusive	22.09	89.57	145.28	40 to 44 "	5.01	4.22	12.97
25 to 29 "	16.88	42.34	81.32	45 to 49 "	2.59	3.67	8.85
30 to 34 "	11.21	21.15	45.75				

The proportion of married soldiers naturally exerts a marked influence on the prevalence of venereal affections; figures for the British army in India, for the six years 1867–72, showing that the percentage of admissions for venereal disease among married men was only one-fiftieth of the percentage for the unmarried. As might have been expected, recent investigations in the British service in India show that cases of venereal disease are much less numerous among abstainers than among those habituated to the use of alcoholics. In the French army, it has been noted in some instances that the amount of venereal disease in a garrison varied directly with the amount of clandestine prostitution; the prevalence of these affections varying directly with the rigor with which the surveillance of prostitutes was maintained. According to Von Tophy, the relative venereal morbidity in the armies of Austria, Germany, France and Italy bears a close relationship to the prevalence of this class of diseases among the civilians in the district in which they are quartered; whence he believes that all measures for the restriction of the disease should primarily be applied to the civil population. The amount of venereal disease is greatly influenced, according to Jeannel, by the virulence of the type of the affection as found in foreign countries and by the facility of communication with the civil classes. Coustan states that in the French army the proportion of venereal disease is very much greater among the troops stationed in large cities than in those in country districts or near small towns.

Prevention of Venereal Diseases.—This depends upon the official application of restrictive measures to the prostitute and to the soldier, together with the effort to raise the moral standard of troops by other than coercive means. Of these, the control of prostitution is the most important, for it is obvious that an infected prostitute may transmit disease to a large number of men in a relatively short space of time.

In the small army of the United States, containing, as it has in the past, a relatively large proportion of married soldiers and scattered in small detachments over a vast territory, the necessity for the sanitary regulation of prostitution has not been forced upon the attention of the military authorities; and the execution of proper measures would, indeed, have been impracticable at home stations. With the altered con-

ditions and changed moral environment which have, however, resulted from recent acquisition of foreign territory and contact with alien races, the subject at once attains a vast importance—assuming that the experience of the United States as regards the occurrence of venereal disease among troops will ultimately not greatly differ in this respect from that of England, France, Holland and other countries holding tropical colonies. That this country may profit in the future from their mistakes of the past, and treat this matter forcefully, practically and with an absence of sentiment is much to be desired, but, in view of the varying political conditions controlling the policy of a republican form of government, a result which is scarcely to be anticipated. It should be emphasized, however, that in the case of no other contagious disease is the affected individual, in this country, permitted to remain a menace to the public health and welfare; and, aside from that false modesty which refuses frankly to admit and openly to limit and control an evil the existence of which it secretly deplores, there is no reason why venereal disease, so far-reaching in its effects and so often transmitted to the innocent and to future generations, should not be subjected to the same official control as is required in the case of any other communicable disease of grave character. That the spread of any other contagious disease may be prevented by the application of suitable measures to the affected individual will readily be admitted; that this rule applies equally in the case of venereal infections is not only apparent in theory but has been demonstrated in practice.

Since no systematic effort has been officially made, within the limits of the United States, to decrease venereal disease in the military service by the control of prostitution—save local attempts at Nashville and Memphis during the Civil War—it is necessary to turn for information on this subject to other nations, whose abundant experience has demonstrated the efficiency of this practice. For many years, the fact has been officially recognized in nearly all European countries that prostitution is the chief means by which venereal disease is propagated, and measures have been employed to restrict its spread by this agency. The official control of prostitution as a lesser evil, in diminishing the results of deplorable though none the less ineradicable vice, is no new thing. Long ago the necessity for some such action was realized if a general syphilitic taint throughout the population was to be averted; and harsh measures—in general keeping with the spirit of the times—were instituted. Thus at Mayence, as long ago as 1497, a prostitute who was shown to have consorted with a syphilitic man, or was herself syphilitic, was branded on the forehead so that she might be avoided. In Berlin, in the year 1700, a law was passed placing all public women under police control, requiring them to be examined as to their freedom from venereal infection at least every two weeks and compelling such as were found infected to enter hospital for treatment. A similar law was passed in France shortly before the French Revolution; the registration of each prostitute with the police of the district in which she lived being also required. Belgium passed a similar law in 1836; Russia in 1843. England passed such an act in 1864 and repealed it in 1888. Italy repealed a similar law in the same year, largely as a result of English influences. Denmark, Norway and Sweden rigidly control prostitution; Spain and Roumania officially

regulate it, but its supervision and control are not as rigorous as in some other countries. Considering the question of the official control of prostitution from the general standpoint, as illustrated by these countries, it may be said that the prevalence of venereal disease is least where sanitary measures are most thoroughly enforced, progressively greater with greater laxity in their administration and greatest where no effort is made toward its control. To demonstrate these points, it is only necessary to glance at the table already given, showing the distribution of venereal disease among the principal armies of the world, and to compare the rates of such armies as those of Germany, Russia and France with those of Italy, Great Britain, Holland and our own service. The army of Japan may fairly be left out of consideration, since these troops are not of the white race, and as already pointed out, apparently possess that relative immunity to venereal diseases, particularly syphilis, which appears to be common to Asiatic peoples.

It is, of course, impossible fully to discuss in a work of this character the influence which the official regulation of prostitution has had upon the army of each individual nation concerned, but a consideration of the results in the British army is highly instructive and may be accepted as being fairly typical of the whole. On examining the figures given in the British Army Medical Department Report for 1883, as illustrating the influence of restrictive legislation in England upon the prevalence of venereal disease, the point which chiefly attracts the attention is the enormous difference between the number of admissions for primary syphilis among troops in the districts within which prostitution was under official control, as compared with the admissions in the stations not under the Contagious Diseases act. This is well shown in the following table, which covers the period 1870–82.

Fourteen stations, under the act.		Fourteen stations, not under the act.	
Average strength	47,394	Average strength	19,218
Total admissions for primary syphilis during period	31,105	Total admissions for primary syphilis during period	29,582

If these figures be compared, it is observed that if the ratio of admissions in the subjected stations had been the same as for those not under the act, the total admissions for primary syphilis would have been 72,952. It is thus obvious that 41,848 men were prevented from contracting the worst form of venereal disease, in this one group of stations, owing to the enforcement of the provisions of the Contagious Diseases act. The number of men constantly in hospital for primary syphilis was only 3.97 per 1,000 in the group under the act, while in the group where restrictive measures were not in force it was 9.16 per 1,000. In May, 1883, the act was practically done away with, the compulsory examination of prostitutes having then ceased; and the following figures are of interest as showing the disastrous results of interfering with such an essential regulation:

SOLDIERS CONSTANTLY IN HOSPITAL, PER 1,000 STRENGTH, FOR PRIMARY SYPHILIS.

Year or Period.	Group of stations under the act.	Group of stations not under the act.
1870–82	3.97	9.16
1883	8.66 } Act	15.81
1884	12.41 } modified.	14.01

ADMISSIONS TO HOSPITAL, PER 1,000 STRENGTH, FOR PRIMARY SYPHILIS.

Year or Period.	Group of stations under the act.	Group of stations not under the act.
1870–82	50	118
1883	110 } Act	188
1884	138 } modified.	160

Browning compares the admissions for primary syphilis at the two stations of Chatham-Sheerness and London, for the year 1875; one subjected to and the second not under the act, the average strength of the garrison of each being about 4,000 men. For the former station, the admissions for this cause were only 17 per 1,000 for the year mentioned, while for London the admissions were 187 per 1,000. For every man admitted for this cause at Chatham-Sheerness, eleven were admitted during the year at London. Before the act came into force, the admissions at Chatham-Sheerness were 94 per 1,000 (average of period 1860–66), while from 1867 to 1882 the rate was reduced to 49 per 1,000. On abolishing the compulsory examination of prostitutes, the ratio of admissions for primary syphilis rose at Chatham-Sheerness, in 1884, to 141 per 1,000, or nearly equal to the rate for London.

The effect of the Contagious Diseases act in the United Kingdom on the number of admissions for gonorrhœa was not so marked as in the case of syphilis; the ratio of admissions for this disease being 84 per 1,000 in the subjected group, while in the stations not under the act the ratio was 105 per 1,000. It is computed, however, that the act prevented about 12,000 cases of gonorrhœa, during the period 1870–82, among the troops at the fourteen stations where the regulations were in force.

Previous to 1885, in the British service in India, lock-hospitals were maintained for the treatment of women suffering from venereal diseases. All prostitutes living in cantonments were registered and subjected to frequent medical examination. In many cases, special quarters were allotted to them in regimental or cantonment bazaars and women evading the rules were subject to ejectment from the military limits. In 1885, the Indian governmental authorities decided that a certain number of these hospitals should be closed, with a view to comparison of the results of these stations and at protected stations; the results obtained in 1887 showing that there had been a marked and progressive increase of venereal affections where the lock-hospitals had been closed, while the rates of disease compared most unfavorably with the rates at the stations at which these institutions had been maintained. As a result of this comparison, the hospitals previously closed were directed to be re-opened; but in 1888 all official control over prostitution in India was abolished by act of Parliament. Since 1887, the last full year of the protective system, there has been the enormous advance of primary syphilitic disease of 137 per cent. and of secondary disease of 188 per cent.; a progressive severity of cases expressed by an average stay in hospital of 31.5 days in 1895 as compared with 26 in 1887; and a temporary inefficiency of the force exemplified by the fact that during the year 1895, out of 68,331 men, there were 36,681 in hospital for the above average period, of whom 22,702 were suffering from syphilis.

The number of men constantly non-effective as a result of venereal disease was 31,664; while the invaliding from this cause advanced from 1.13 per cent. under restrictive measures to 5 per cent. in 1895. Concerning the prevalence of venereal disease in 1894–95, the army sanitary commission wrote: "The results of experience in India since 1885, when a number of lock-hospitals were closed, and in subsequent years when all restrictive

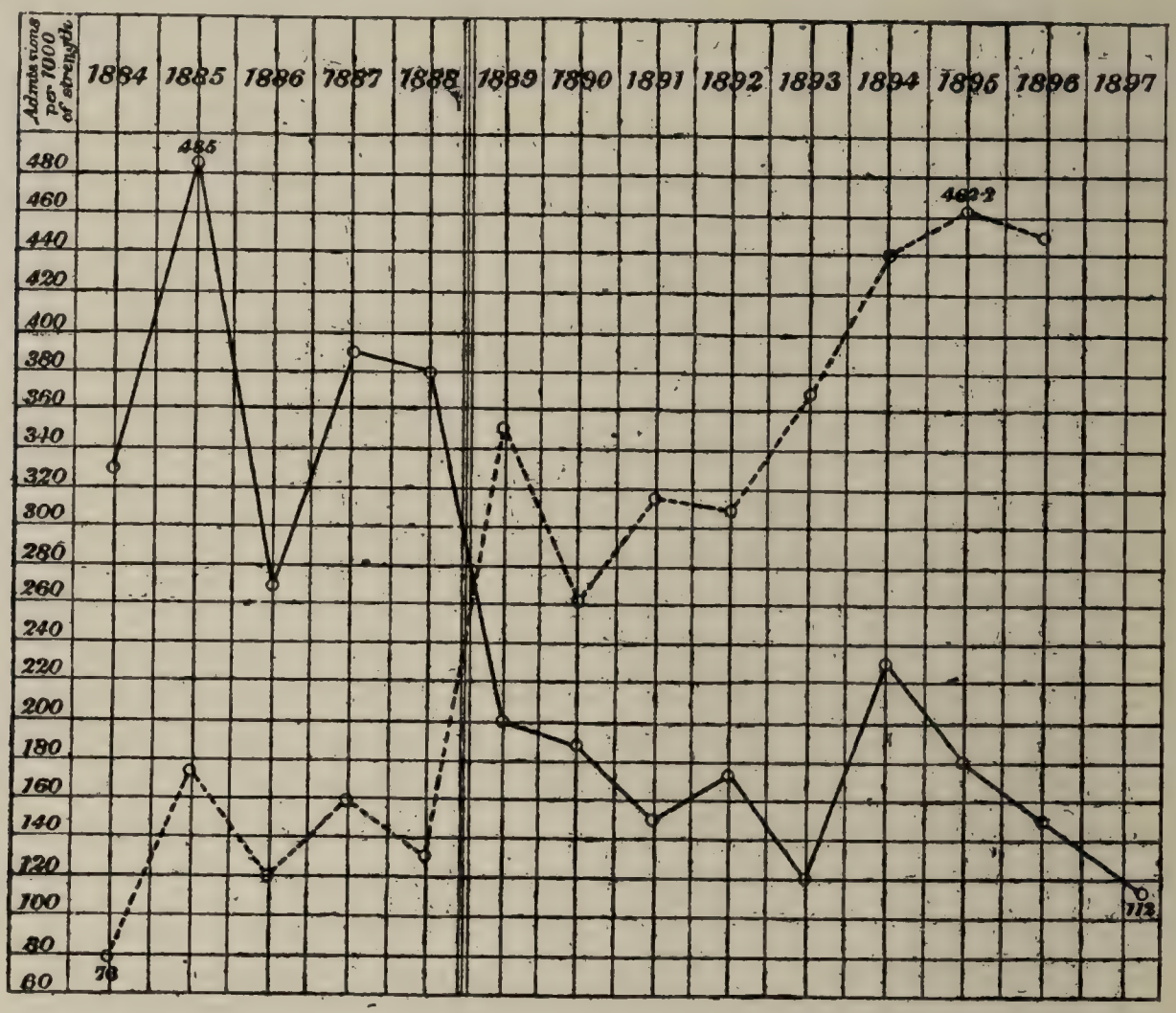


FIG. 369.—Chart Showing the Influence of Laws Controlling and Regulating Prostitution in Rohilkhand District, India, and Cape Town, South Africa, upon the Admissions, per 1,000 Strength, for Primary and Secondary Syphilis from the British Troops Stationed at these Points. (After Browning.)

Black line, Cape Town; dotted line, Rohilkhand.

Cape Town, without Regulations,	1884–1888,	average	371.
Rohilkhand, " "	1889–1896,	"	370.
Rohilkhand, with "	1884–1888,	"	132.
Cape Town, " "	1889–1897,	"	168.

measures were gradually removed, show that a progressive increase of venereal diseases has taken place among the British troops serving in India; and there is unfortunately no assurance that this increase has reached its limits."

In the year 1889, a Contagious Disease act was brought into force at Cape Town, South Africa, and at the same time all regulations for checking the spread of venereal disease were abolished in India; so, for a period of eight years, it is possible to compare India, minus regulations, with Cape Town and a Contagious Disease act in force. For the five years previous to the act coming into force at Cape Town, the average admissions among troops on that station for primary and secondary syphilis were 371 per 1,000 of strength. The troops in the Rohilkhand district of India, for the years 1889–96, had almost exactly the same proportion of admissions, viz.: 370 per 1,000, neither station being under a Contagious Disease act. For the nine years 1889–97, after prostitution was officially regulated, the admissions for venereal disease at Cape Town were reduced to 178 per 1,000

strength; while Rohilkhand, during the like number of years, 1880–88, prior to the removal of all official control over prostitution, had nearly the same number of admissions for this cause, 134 per 1,000. The chart on page 834 graphically shows the influence of the acts upon the admissions for syphilis; the heavy vertical lines marking the abolition of all restrictions in India being followed by an immediate and extraordinary increase in the number of cases of this disease, and also showing the point at which unrestricted prostitution in Cape Town came under official control, a remarkable and permanent decrease resulting. To such an unanswerable argument as to the value of controlled prostitution it would be almost superfluous to add.

Browning states that previous to restrictive measures coming into force at Cape Town, venereal diseases of all kinds were rampant and the admissions to the military hospitals, for these affections, appalling; the latter having reached a rate of 828 per 1,000 strength. The average for the years 1884–88 for all forms of venereal disease was 674 per 1,000, while the average for the years 1889–97, after prostitution was regulated, was only 349. This was not a gradual fall which might be accounted for by an improvement in morals, but a sudden descent, as shown in the following

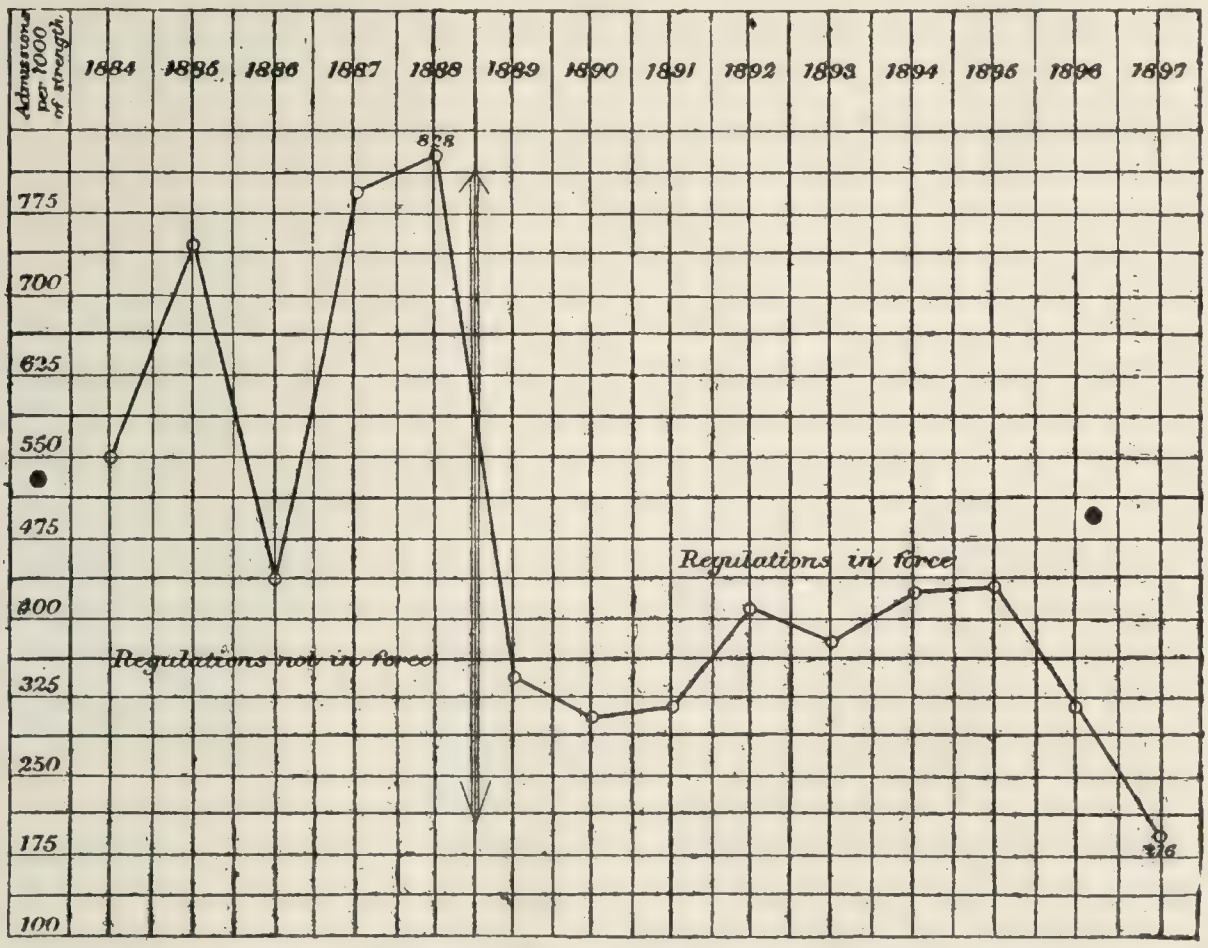


FIG. 370.—Admissions for All Venereal Diseases, per 1,000 Strength, Among the British Troops at Cape Town, Showing their Relative Prevalence Before and After the Regulation of Prostitution. The vertical lines mark the institution of official control. (After Browning.)

diagram, from 828 per 1,000 in 1888 to 347 per 1,000 in 1889. In 1897 the rate had been further reduced to 216 per 1,000.

Browning concludes that the Contagious Diseases act of the Cape of Good Hope has "been the means of preventing thousands of soldiers in the garrison at Cape Town from being incapacitated by venereal diseases" and that "the men who still contract such complaints suffer from a milder form than existed prior to the act coming into force." He believes that "the act is a humane one, relieving the sufferings of hundreds of prosti-

tutes and also alleviating the distress of women who, though not strumpets, contract venereal disease."

In the province of Pinar del Rio, Cuba, during its recent occupation by United States troops, the following order was published and enforced: "Clandestine prostitution will not be tolerated. Prostitutes shall be registered. They shall live in such locations as are indicated. Each prostitute shall have a book. In this her name, age, nationality and address shall be recorded. She shall be examined at least once a week by a physician, and the examining physician shall sign the book. This examination shall be good only for one week. Any prostitute engaging in her trade when her book is not signed to date shall be punished. She shall not change her residence without the permission of the sanitary inspector. The proprietors of houses of prostitution will be held accountable for the condition of the houses, and of the inmates; also for the orderly conduct of those living in or visiting such houses. No liquor shall be sold, given away or drunk in houses of prostitution. Each prostitute will be required to provide the means necessary for securing her own and her visitors' cleanliness. Cases of venereal disease must be at once reported to the sanitary inspector. When venereal disease is traced to any particular person, such person will be subjected to punishment." As to the results which followed the enforcement of this order, the chief surgeon of that department writes: "In connection with the matter of regulated prostitution, this command has been in Cuba three months and numbers 3,000 men. These men have free access to the towns. I have not been able to find more than nine men who have contracted venereal disease in the Department of Pinar del Rio."

In certain cities of the Philippine Islands, similar rules for the regulation of prostitution have been enforced. At Jolo, in the Sulu archipelago, the occupation of the town by our troops was followed by the appearance of about forty Japanese prostitutes. At first no effort was made to control these women, and, according to Steer, much venereal disease appeared in the command. As a result, the regulation of prostitution was decided upon; strict rules were enforced, among them being the weekly examination of the prostitutes and the exclusion of all outside individuals, as sailors and commercial people, from the houses. A lock-hospital was also opened, which the women were compelled to enter upon the slightest suspicion of venereal disease and in which they were kept until their recovery was complete. With regard to the men, frequent inspections of the person were made. Some difficulty was experienced with cases of chronic gonorrhœa, as the services of as many men as possible were required, but the problem was finally solved by making up the garrison of a detached block-house from such cases, with an officer detailed to command them and a member of the hospital corps assigned to ensure the proper carrying out of treatment. Under these precautions, the amount of venereal disease was reduced to less than one per cent.; there being but five cases of venereal under treatment, at the time of the report, out of a command of seven hundred and fifty men. To show the effect of this system in reducing venereal, Steer states that from one battalion which came to Jolo after service in the islands of Cebu and Leyte, inspection showed seventy-eight men with venereal infections—a number being syphilitic. On the arrival of this battalion, the houses of

prostitution were closed, and kept so until the men had been inspected and those who were diseased had been isolated and prevented from transmitting their affections to others. As a result of the control of prostitution at Jolo, not a case of primary syphilis has occurred among the soldiers during the year its regulation has been enforced, the venereal diseases which do occur are mild in character and are notably free from the complications so frequently observed in other parts of the Philippines. The prostitutes are restricted to certain houses and are rarely seen on the streets or at the windows, so there is little to shock the casual observer. As a result of the presence of these women, trouble with the surrounding native Mahommedan population is avoided.

In the report concerning the sickness among the British troops composing the Dongola Expeditionary Force, in 1896, the chief medical officer says: "On first arriving at Wady Halfa there was some trouble found in checking clandestine prostitution. There were a large number of native women who were living just outside the English lines, and it was from these women that the men contracted disease. There was a licensed brothel under supervision in the native town of Wady Halfa, and the inmates were periodically examined. Very few cases of disease were contracted there. Stringent police precautions were taken and a military patrol was placed outside the camp to prevent women from coming near, and this answered so effectively that after a few weeks the nuisance was almost stopped and there were hardly any admissions afterward for venereal."

For the period 1863–65, the Italian army had an admission rate for venereal disease of 120 per 1,000; this falling in 1874–76, as the result of sanitary inspection and careful control of prostitution, to 66 per 1,000. In 1888, under the influence of English ideas, the Italians abolished the regulation of prostitution; a venereal rate of 47.5 per 1,000 strength, of the previous year, being increased to 66.6 in 1889 and 93.3 in 1893.

In view of such facts as are quoted above, there can be no doubt that the intelligent regulation of prostitution results in a great decrease in venereal; this to be accomplished by a system including careful registration, official surveillance and weekly medical inspection, so that the addresses of prostitutes may be known, their movements traced and any diseased condition recognized. The latter requirement is of the greatest importance—a fact of which the British Sanitary Commission in India was fully convinced when it recently reported: "We are satisfied from the evidence that the frequent examination of women is the most efficacious method of controlling the disease." These examinations should be made in private and only in the presence of official examiners.

Clandestine prostitution should be discouraged as far as possible, as furnishing a high rate of venereal. Colin noted that of 32 syphilitic French soldiers, 14 were infected by public prostitutes and 18 by women employed in so-called wine shops. All common prostitutes should be segregated within well-defined limits and public solicitation severely punished. Brief printed instructions should be furnished these women as to the dangers and prevalence of venereal, and the importance of cleanliness as a measure of prophylaxis. Next to medical inspection, it is probable that care in maintaining cleanliness of the person is the most important

factor in preventing the spread of disease venereal; it having been experimentally determined that infection from the non-syphilitic venereal sore may usually be prevented by a thorough cleansing of the parts with soap and water if done within ten minutes from the time of exposure. When diseased, such public women should be at once isolated in a proper institution until restored to health. Apart from the great importance of such action upon the general welfare, it is also a matter of humanity to these unfortunates that they should have the benefits of medical treatment, with rest and care in hospital, until they are cured. Obedience to these regulations should be enforced by police authority; but public exposure, as far as the occurrence of venereal disease is concerned, should be prevented as far as possible. It should not be forgotten that when official control becomes too rigorous the number of avowed public women undergoes diminution while clandestine prostitution increases. The proposition is not here advanced that the Government should provide prostitutes for troops, as has been done by the British military authorities in India, nor that a native concubine should be officially allowed and supported for each soldier, as is said to be the case at present with respect to the Dutch troops at certain stations in Java. There should be no official encouragement of vice; but the regulation of vice is not its encouragement, and such women as have voluntarily chosen to adopt a life of prostitution and who come within the sphere of military control, as may well be the case under many circumstances, should be prevented, so far as possible, from spreading loathsome disease among the men whose health it is the duty of the sanitary officer to guard—the latter, in this manner, indirectly shielding the civil population to which the soldier returns on his discharge. That the men who consort with prostitutes do so at their own risk is a specious argument which might be applied as justly with reference to any other infectious disease. The public welfare must be consulted, for the soldier himself is frequently not the only sufferer from his transgressions, but may transmit his affection, in many ways, to the innocent. With the ethics of the question the sanitary officer has nothing to do. Prostitution always has existed, and probably will continue to do so while the world lasts and human nature is weak. The most severe laws of ancient times, even the death penalty, failed to stamp it out. The military service finds these social conditions—it does not create them—and it is the duty of the sanitary officer to limit and modify their effects by every means possible. Of these, the regulation of prostitution is the most efficacious.

Since military garrisons often attract to their vicinity lewd women of the lowest character and largely subjects of venereal affections, great care should be taken to prevent loitering or importuning by this class, or by their male associates, within the limits of the command. Particularly in the tropics it is desirable that no females should be employed in or about the barracks, since there is evidence that such women are frequently the source of aggravated forms of venereal disease.

In addition to the control of the women chiefly concerned in its dissemination, the prophylaxis of venereal disease among troops requires the application of suitable preventive measures to the soldier. The large amount of venereal disease occurring among troops—a condition entirely preventable and dependent upon vicious indulgences—has led many to

suggest the imposition of penalties upon such soldiers as may offend in this respect. It has been proposed that those incapacitated for duty from this cause be deprived of their pay while rendering no service to the Government; that their privileges be restricted or that confinement be imposed. In the French army, a period of imprisonment was at one time imposed upon every venereal case after discharge from hospital; but, as this led the men to conceal their diseased condition from the medical officers and either go without treatment or place themselves in the hands of unqualified practitioners, the order was revoked. It is certainly subversive of discipline and unjust to the more moral class of men to require them to perform the extra duty which results from the entrance into hospital, as a result of their own misconduct, of those on whom such duties should rightfully have devolved. Such a condition practically puts a premium upon participation in vice, and apparently the only way by which the latter can be punished is through compulsory inspection of the person, as is required in the German army. Quite recently this plan has been tried in several commands of our own service and has not aroused the opposition on the part of the men which was at first anticipated; it would be of much sanitary advantage if the plan were more generally adopted. During the occupation of Cuba, an order was issued on this subject in the Department of Matanzas, of which the following is an extract: "There should be a weekly examination of all the enlisted men in the command made by the medical officers, and the company commanders should be required to be in attendance. The men should be stripped and this examination should be complete as far as relates to any outward evidences of venereal disease or other infections. A list of all the men found infected with venereal troubles should be made out under the direction of the company commander and posted conspicuously on the bulletin-board or in the barracks of each company organization. Among these thus affected, only those who are actually incapacitated from performing their duties should be placed on sick report, the others being required to perform all duties. The privileges of the canteen and all pass privileges should be withdrawn from all whose names are thus posted and extra severe punishment meted out to those who are detected violating this rule. As soon as any one thus listed is, in the opinion of the surgeon, free from all manifestations of venereal infection the surgeon should notify the company commander, so as to enable the latter to take his name from the list. This course cannot be construed into actual punishment of the enlisted men, for the reason that in taking away his canteen and pass privileges it is merely in the nature of removing the causes which tend to retard his recovery. A weekly inspection is necessary, as there is no other way by which it can be determined whether or not the individuals are infected."

Where measures for the control of prostitution can be carried out, the soldier affected with venereal disease should be required to state where and from whom it was contracted, with a view to the proper segregation and treatment of the woman indicated. In the British service, however, during the existence of the cantonment laws, some difficulty was met with, according to Welch, in the attempt to identify the source of venereal infection through the unwillingness of the soldier to expose his co-partner in vice.

Under present conditions, many soldiers affected with venereal disease hesitate to declare its existence through the official publicity necessarily given to such cases, and their reluctance to have their names entered upon the records in connection with affections of this character. Thus of two companies aggregating 170 men, which had recently returned from two years' service in Porto Rico and which were inspected by the writer, no less than 37 cases of concealed venereal disease were found, of which 11 were syphilitic. These had not been declared through fear that they might prove a possible obstacle to re-enlistment or the subsequent attainment of a pension. As a result of failure on the part of the soldier to report his condition, the latter, in many instances, is aggravated by being left either without treatment or by the employment of patent medicines or unskilled advisers; while the sufferer is a constant source of danger to his associates. Where venereal disease is concealed, the offender, if detected, should be severely punished; and it should be thoroughly understood by the men that it is greatly to their own interest, in the way of cure, to declare the existence of such an affection as soon as its appearance is noted. Further, all non-commissioned officers, knowing of the existence of cases of venereal disease in their troop or company, should be held responsible for the prompt appearance of the sick men before a medical officer. A soldier who chronically exposes himself and undergoes repeated infection should be regarded as morally unfitted for the military service and a candidate for discharge. Such a man is a nuisance in a company and is so regarded by the good men, who shun his contact and are suspicious of the bath-room and other conveniences which all use in common. Spending a large part of his time in hospitals, the services of such a man are often of but little value to the Government.

It would certainly be of advantage to the military service if short lectures by medical officers, particularly at recruiting depots, were delivered at suitable periods for the purpose of acquainting soldiers with the grave and far-reaching consequences that are likely to result from immoral conduct, particularly with respect to clandestine prostitution; the importance of early treatment in the case of venereal disease and the dangers resulting from its concealment; the intractable character of syphilis and the necessity for prolonged medication; the dangers resulting to the healthy from the presence of concealed venereal disease in barracks. It is a question whether a general discussion of the personal means sometimes employed in the prevention of venereal infection would be advisable; and the sanitary officer should carefully avoid assuming a position which might be construed by the men as in any way favoring the practice of sexual gratification. Chastity should be inculcated, and the too common idea that sexual continence increases sickness and mortality should not be encouraged.

USE OF TOBACCO.

The moderate use of tobacco, both in garrison and in the field, may be regarded as necessary to the comfort and happiness of the average soldier. It is certain that among many individuals the want of this article causes even more hardship than the lack of food; and its deprivation, as a means of punishment, is said to figure among the disciplinary measures of the

German army. In the military service, tobacco is ordinarily employed for smoking, and its use for chewing is as exceptional among soldiers as it is frequent among sailors. Smoked in moderation after meals, it stimulates gastric secretion, aids digestion and increases peristalsis; where the supply of food is insufficient, it markedly diminishes the sensation of hunger. Korloff, during the last Russo-Turkish War, specially studied its properties in the latter respect, as a result of which he recommended that a daily allowance be issued to the Russian troops; and in our own service tobacco has wisely been incorporated as one of the components of the emergency ration. Experience shows, however, that smoking during the heat of the day, particularly while on the march, increases thirst and leads to unnecessary drinking—the same result, through the loss of salivary fluids induced by frequent expectoration, following the use of tobacco by chewing.

Tobacco promotes reverie, overcomes weariness, relieves *ennui* and over many individuals has a markedly soothing influence. In camps of long standing, the soldier sooner or later becomes fretted by the monotony of the life, and tobacco is largely used; nominally to help pass the time but in reality for its sedative influence on an unemployed nervous system. Under the latter conditions, its consumption may become sufficiently great to demand the attention of the medical officer, for excess in its use is productive of positive evils. Arnold considered it to be an abuse of tobacco if the daily consumption of this article, per man, exceeded half an ounce. It is impossible, however, to predetermine the minimum quantity which would be harmful to each individual—but shortness of breath, obscure pains around the heart and nervous irritability are indications to reduce or abstain from the use of tobacco. More pronounced symptoms resulting from its use are loss of appetite and impaired muscular force, vertigo, alteration of vision, loss of memory and progressive weakening of the mental faculties. In general, however, tobacco can be regarded as harmful only to soldiers of a highly neurotic tendency and to those of insufficient will power properly to restrict its use. Whatever its possible theoretical dangers, the hospital records of our army demonstrate that little justifiable criticism can be made of the present use of tobacco by American soldiers, nearly all of whom habitually employ it without the production of any ill effects whatever.

Smoking should be prohibited in barrack dormitories and allowed only in the open air or in rooms specially designated for the purpose. The individual hygiene of the smoker consists in maintaining cleanliness of the mouth and of the pipe, cigar- or cigarette-holder employed; in abstaining from the practice of inhaling the smoke into the lungs, from smoking before breakfast and in a proper limitation of the amount of tobacco consumed.

TATTOOING.

This is a wide-spread custom of great antiquity, especially common among people of a rudimentary civilization. Among such, it is used not only for purposes of adornment but also as a means of readily identifying the individual and determining his nationality. Among civilized peoples it is affected chiefly by those of a low social and criminal class, and may

fairly be looked upon as one of the stigmata of degeneracy; the more intelligent men not being partial to this method of ornamentation. A large proportion of tattooed recruits are enlisted from cities and large towns. Among soldiers, imitation is the most important factor in inducing tattooing, the great majority unthinkingly following the example set by others —a former sailor being frequently responsible for the performance of this operation on the persons of his comrades. Much of the tattooing noticed on recruits will be found to have been done on the appearance of the genital function; often in commemoration of an attachment, illicit or otherwise. The marking is generally limited to those parts normally covered with clothing, the site most commonly selected being the anterior aspect of the forearm—though other portions of the body, as the arms, legs and trunk, are not spared. As observed by the recruiting officer, the most common devices are initials, dancing and nude female figures, flags, ships, anchors, wristlets, hearts and clasped hands. This form of decoration is usually resorted to from motives of vanity. Others are selected as being symbolical of occupation, as the whip and horseshoe, or as indicative of feeling or state of mind, as shown by an embracing couple. Indecent designs, so common among the criminal classes, are not seen in our military service, since the possession of tattooing of this character constitutes a bar to enlistment. In city-bred recruits, particularly those who have had a street life, small dots are frequently noted on the web between the thumb and first finger. These, varying in number from two or three to eight or nine or more, irregularly distributed or arranged in circular, stellate, triangular or rectangular form, are evidence of membership in certain organizations, serving the same purpose in handshaking as the fraternal grip of more pretentious and laudable societies.

The operation of tattooing, among soldiers, is done by pricking; and tattooing by scars, though abrasion of the cuticle, is not common. The coloring matter employed is usually India ink, wood-charcoal or perhaps laundry blueing—the red color being given by vermilion. The operation not rarely causes inflammation of the lymphatic glands and sometimes abscess. More rarely a condition of marked sepsis results, and Berchon cites four cases in which amputation of a limb was required for this reason. As usually carried out, the colors are moistened in the palm of the hand with the saliva of the operator. The men who do this work are sometimes affected with constitutional disease; and Chenisse, Robert, Bergasse and others have observed a large number of instances where syphilis has been transmitted by this procedure. This is especially common in the tropics, where the native operators are not exceptions to the more general syphilization of their race. In the same way, inoculation with tuberculosis has frequently occurred; Callings and Murray reporting an interesting series of cases in which the tuberculous manifestations appeared from three weeks to one month after tattooing done with colors rubbed up with the saliva of a phthisical operator.

As to the proportion of tattooed individuals in the military service, Lombroso noted that of 2,739 Italian soldiers only 1.2 per cent. were so marked, while as much as 10 per cent. of more than 6,000 adult criminals had subjected themselves to the operation. For the German service, Baer found the above condition to be reversed; only 2 per cent. of crimi-

PLATE VIII.



Common Forms of Tattooing Among Soldiers.

nals being tattooed as compared with 9.5 per cent. of soldiers. For our own service, no definite figures upon this point are available, but the proportion of tattooed soldiers is certainly very considerable.

AMUSEMENTS OF THE SOLDIER.

The monotony of life in garrison, and especially among troops on foreign service or in encampments of long standing, will, unless interrupted, become extremely irksome. Under such conditions, nostalgia is very liable to develop, especially among young recruits and new regiments. This affection was very common among the volunteer troops first sent to the Philippines, affecting officers as well as men; one Nebraska regiment having at one time 95 cases reported by the regimental surgeon as "No diagnosis, probably nostalgia." In many instances, the medical officers themselves were affected with this complaint and the result was a sick-list wholly out of proportion to the actual disease present. After the novelty of strange environment and new duties has worn off, the soldier suffers from sameness of occupation and—sooner or later—from the results of comparative idleness. All officers serving with troops should fully appreciate that *ennui* is at the foundation of much of the physical and most of the moral evils by which the efficiency of the soldier is impaired. Idleness, discontent, insubordination, vice and sickness occur in logical sequence; and, while most officers will possess internal resources affording congenial occupation to themselves, suitable employment and means of distraction must be found for the enlisted men. For this purpose, a sufficient amount of fatigue work daily, if carefully planned with reference to a definite object, will do much toward maintaining the mental and moral as well as the physical tone of troops; besides, at the same time, providing many comforts and ministering to the ever-present sanitary needs of the command. Where work of this sort is scarce, it should be so economized as to provide a few hours' employment daily—for the time soon comes when drills alone cease to afford sufficient diversion. Work merely for work's sake is undesirable and promotes discontent, but troops will cheerfully perform any labor which apparently tends to their safety and comfort. Marches into the surrounding country, temporary camps from garrisoned posts, field manœuvers, the construction of entrenchments with practical illustration of their defence and attack—all are methods of maintaining the mental, physical and military efficiency of the command. Pedestrianism should be particularly cultivated among infantry troops and prize matches arranged for suitable occasions. In cavalry commands, trick and Cossack riding will be valuable to both men and animals. Horse-racing affords an interest to all; and target practice—not formal duty-firing, but competitive trial between teams from different organizations—will give a break in the monotony. Hunting and fishing should always be encouraged among troops as affording a most valuable means of recreation and change of diet; at the same time familiarizing the soldier with the use of his weapons, with the topography of the surrounding country and with the science of woodcraft. Gymnasium work, applied gymnastics and athletic field-sports not only improve the physical condition but also the mental state of the men. Field-days for competitive athletics should be held at suitable in-

tervals, and all out-of-door games, especially such as football and lacrosse, should be encouraged in every possible manner.

It is especially during the enforced monotony of winter camps, or with small detached commands in the tropics during the rainy season, that systematic effort should be made to amuse and interest the men. The frequently narrow quarters and perhaps imperfect means of maintaining cleanliness, the confinement within doors by the condition of the roads and weather, the long uneventful waking hours, the prolonged sexual abstinence and the tread-mill round of minor and annoying drudgery—all tend to disturb the nervous balance and lead to attempted relief. If alcoholic liquors can be obtained at such times they are much abused, and the excesses tell on the nervous system by depressant action. Gambling is the favorite excitement of many in spite of its official prescription; and prolonged sessions, implying loss of sleep and disorders of assimilation, are held in cramped positions and frequently foul atmospheres. Much too common a vice, gambling should be discouraged in the military service as tending to develop a class of sharpers who fleece their comrades and beget bad feeling directly to the prejudice of good order and discipline. Under the above conditions, tobacco and excessive sleep are resorted to as aiding to pass away the time under conditions of *ennui*; while vicious dealings with the generative function may, with certain individuals, be called upon to furnish in this way the nervous excitement required. To turn the attention into more healthful channels, varied indoor amusements, in addition to outdoor sports, should be officially encouraged. Reading-rooms and small libraries should be established, and dramatic and variety entertainments projected. Under all circumstances, music dispels mental depression and stimulates and enlivens those under its influence. Bands are of great value, especially with unseasoned troops; and the formation of musical clubs among the men should be encouraged for this reason. Literary and debating societies introduce a town-meeting element which has no place in the military service; nor is it reasonable to expect the greater portion of the enlisted force to become greatly interested in intellectual pursuits. For this class of men, the canteen furnishes a congenial club in which their social needs are best satisfied.

With large commands, men can always be found possessing special talents—as actors, vocalists or athletes—for amusing others; and such should be promptly sought out, organized into a company and encouraged by official recognition and assistance in catering to the amusement of the troops. Under the monotonous conditions of camp life, officers will do well to encourage the energies, while directing the efforts, of the leading spirits of their commands. There are always certain men of initiative in creating diversion and such carry the mass with them and bring amusement to all. Their efforts should be promoted in every possible way, as being of the greatest value in the prevention of *ennui* and discontent. In large commands, an officer should be detailed to take charge of all public amusements—including theatrical performances, shooting, racing and competitions of all sorts. If active and enterprising, he will keep many names off the sick-list and tide the command through the period of tedium with undiminished nerve force.

It may be added in this connection that "the effect of aggregating or massing together a large number of men is a peculiar psychological prob-

lem. A mob may readily be induced to perform acts the most illegal and irrational; and an army, if the contradiction of terms may be employed, is a disciplined mob. Men who, at home, are correct and dignified members of society, when gathered into an army and removed from home restraints will speak and act in violation of propriety, decorum and law. The tendency to a disregard of law, hygienic as well as other, becomes the rule rather than the exception. The lapse of time and the power of discipline may diminish this tendency to lawlessness, but it never entirely disappears from an army in which fighting is not the constant business of life."

INSANITY AND SUICIDE.

Mental diseases have undergone a considerable diminution in our service during comparatively recent years; this undoubtedly resulting from the greater provision officially made for the intellectual needs and recreation of the soldier, together with the concentration of troops near large centres of population. With the present establishment of small garrisons throughout the tropical islands, an increase in insanity may be expected. Among our troops on foreign service, home-sickness appears to be a potent factor in producing a condition of melancholia. During the past three years, the isolation of troops, their lack of knowledge of the native language, their enforced confinement to garrisoned towns, and the constant nervous strain incident to continued preparation against attack by the enemy, all combine to produce a mental condition, which, for want of a better name, is called insanity, and which is often completely and effectively cured by the trip from the Philippines to the United States. That the condition is a serious one is evidenced by the fact that the majority of suicides occur in this class of cases. The following figures show the rates for mental diseases in our army for a period of thirty years:

Year.	Admissions per 1,000 strength.	Year.	Admissions per 1,000 strength.	Year.	Admissions per 1,000 strength.
1868	1.7	1878	1.5	1888	1.7
1869	1.5	1879	1.9	1889	1.3
1870	2.1	1880	2.1	1890	1.3
1871	2	1881	2.5	1891	1.5
1872	2.4	1882	2.8	1892	1.9
1873	2.2	1883	3	1893	1.3
1874	1.8	1884	2.1	1894	.9
1875	2.2	1885	1.4	1895	.7
1876	1.4	1886	1.4	1896	.8
1877	1.6	1887	1.9	1897	.8

In opposition to the conditions prevailing in our service under conditions of peace, insanity would seem to be steadily on the increase in the

Year.	Number of men invalided for mental alienation.	Year.	Number of men invalided for mental alienation.	Year.	Number of men invalided for mental alienation.
1877	62	1882	81	1887	130
1878	94	1883	64	1888	150
1879	77	1884	73	1889	158
1880	63	1885	120	1890	192
1881	82	1886	112		

French army; the figures in the preceding table referring to French troops on home service and in Algeria.

In the British army, the rates for mental disease, for the ten years 1887–96, are given as follows:

Station.	Admissions per 1,000 strength.	Station.	Admissions per 1,000 strength.
England	1.2	Bermuda	1.5
Scotland	1.8	West Indies	.7
Ireland	1.6	Ceylon	1.3
Gibraltar	1	China	1.2
Malta	1.7	Straits Settlements	1.5
Canada	.8	India	1.7

From the above figures, it is seen that tropical service under ordinary conditions, contrary to what is commonly supposed, does not appear greatly to increase the liability to insanity.

Race appears to be a strong factor in determining the occurrence of insanity; thus for the decade 1888–97 the admission rate in our army for this cause, per 1,000 strength, was 1.23 for white troops and but .68 for colored troops. Undoubtedly the comparatively dulled mentality and indifference to the future which characterize the negro race has much to do with bringing about the much lower rate for insanity in the case of the latter, but the remarkable abstinence manifested by colored troops with respect to the use of alcoholics must not be overlooked in this connection. As bearing out the theory that individuals possessing a higher order of mental attainments and a more lively sense of responsibility are more liable to develop insanity, Coustan states that in the French army, for the period 1891–94, the admissions for this cause, per 1,000 strength, were .80 for commissioned officers and but .31 for non-commissioned officers. For the same period he found the admission rate for privates having more than one year's service to be .39, while for those having less than one year's service it was .53. This increased liability to mental disease among recruits is undoubtedly due to the fact that in the French army, maintained by forced military service, many young men are separated from home and friends against their wish and thus become subjects of intense mental depression. Further, the most careful physical examination may overlook a tendency to mental instability in a recruit, which may afterward be quickly developed under the conditions of military discipline, the monotony of garrison life or the excitement of campaign.

The military spirit, which naturally cultivates indifference to life, is undoubtedly favorable to self-destruction, and does much to raise the rates for suicide in the military service above those prevailing in civil life. In addition to this feeling, the soldier, constantly under the control of another, separated from home and friends, often occupying isolated and lonely stations and performing monotonous duties, is more prone to melancholia and mental depression and the tendency toward desertion or suicide occurring therefrom. In the United States service, since the Civil War, the rate for suicide increased considerably until within the last six years; during which time there has been a sudden and great diminution. For various years, the rates have been as follows:

Year.	Suicides per 1,000 strength.	Year.	Suicides per 1,000 strength.
1868	0.44	1889	0.83
1872	.51	1894	.79
1878	.63	1896	.43
1883	1.10	1897	.39

In 1898, a year of war, the rate greatly diminished; being only .26 per 1,000 strength. This reduction in rates shows the influence of the excitement and novelty of field service in preventing a tendency to self-destruction. This fact has been noted in other armies; thus out of 401 consecutive suicides in the French army, not a single one occurred during the month of September, when the annual manœuvers are carried on. The desirability of furnishing sufficient and agreeable mental occupation for troops is thus emphasized.

The suicides in our service, for the seven years 1887–93, amounted to a total of 134 cases—7 officers and 127 enlisted men. These were divided, according to branch of service, as follows:

Infantry	64	Engineers	2
Cavalry	28	Medical and Hospital Corps	7
Artillery	15	All others	13
Ordnance	5		

Of these suicides, 51 were under 30 years of age, 56 were between 30 and 40, and 27 were over 40. The methods of self-destruction employed were:

Gunshot	97	Drowning	4
Poison	26	Throat-cutting	3

and 1 each by severing radial artery, suffocation, strangulation and crushing by railroad train. In 37 instances, the causes were undetermined; in the others, the reputed causes were as follows:

Alcoholism	42	Losses by gambling	2
Despondency	12	Charge of theft	2
Insanity	10	Jealousy	2
Love troubles	6	Home-sickness	1
Temporary mental aberration	5	Nervous depression	1
Fear of court-martial	5	Failure to obtain promotion	1
Domestic troubles	3	Tired of living	1
Fear of results of syphilis	2	Distaste for service	1

For the four years 1894–97, only 3 of the 58 suicides reported occurred in the first year of enlistment; thus corroborating the belief that self-destruction prevails chiefly among old soldiers—among whom the rates for alcoholism are also disproportionately high. It is obvious that in our army, recruited by voluntary enlistment and for comparatively short terms of duty, the suicides resulting from dislike of the service or other reasons depending upon a military life are much less frequent than in foreign armies maintained by compulsory enrollment.

According to Millard, the rate per 1,000 for suicides in the entire British army, during the period 1852–56, was .155; for the period 1859–66, the rate was .26; in 1866–70, it was .443. In 1873 it had fallen to .25. For the British troops on the home stations, the rate was .23 in 1897, .21 in 1896 and .20 as an average for the preceding ten years. For stations outside the United Kingdom, these latter rates were practically

doubled. In most cases, the causes of suicide were stated to be unknown; in others, they are variously reported as hypochondriasis, disappointment in love, excessive drinking, dislike of the service, fear of punishment, insanity following diseases like malaria and typhoid fever, and "temporary insanity." The chief methods selected for self-destruction, in order of preference, were shooting, hanging, drowning and throat-cutting.

A number of years ago, suicides were so frequent among the British troops at certain stations as to give rise to much concern and cause the adoption of measures for its repression. Thus Davy states that where three suicides occurred in succession in a regiment stationed at Malta, the body of the last suicide was officially disgraced, being dragged around the barrack-yard by an ass in the presence of the troops and then buried in unconsecrated ground. The effect of this procedure was not known, as the regiment was shortly removed to another station. The same writer, speaking of the conditions existing at that time, says: "It is mostly on foreign stations that suicides are committed, and chiefly on islands from which there is no escape. In other stations where there are opportunities for desertion, the latter is the prevailing offence rather than suicide."

Among the French troops serving at the home stations, the rate for suicide, as given by Viry, was .47 for the period 1862–69 and .29 for the years 1872–90. In a study of 69 cases, 9 of which occurred in sergeants, Arnould divided the causes as follows:

Fear of punishment	21	Disappointment in love	9
Mental alienation from disease,	13	Hypochondriasis	8
Unknown	12	Alcoholism	6

Viry states that only one-sixteenth of the suicides among French soldiers are attributed to dislike of the service—the greater number being due to the fear of punishment, brought about by neglect of duty and not by the severity of discipline. In Algeria and Tunis, for the period 1872–90, the suicide rate was .68 per 1,000. As is the case with insanity, suicides in the French army are influenced in their frequency by rank and length of service. Thus for the period 1891–94, the respective rates for suicide, per thousand of each class, were as follows:

Rank and service.	Rate per thousand.
Non-commissioned officers	.68
Privates of more than one year's service	.22
Privates of less than one year's service	.36

It is thus seen that where compulsory military service is required, the rates as regards the suicide of old soldiers are reversed as compared with those for our own army. In the Oran expedition of Bugeaud, in Algeria, a large number of the men who fell from the ranks, overcome by heat and exhaustion, are stated to have committed suicide.

In the Prussian army, for the period 1829–38, Baudin states that the suicides averaged .50 per 1,000 strength. From 1846 to 1873, the rate was .46; from 1867–72 it was .60. For the entire German army, 1873–78, the rate was .61 and from 1878–88 it was .67 per 1,000. In 1896–97 it had fallen to .44; there being 225 suicides and 87 ineffectual attempts at self-destruction. The Saxon army-corps is said to have had an unusually high rate; the suicide rate for a long time averaging .92.

As a whole, the rate for the German army is nearly twice as great as for the French service. In 1889–90, the proportional number of suicides in the German army, calculated for each thousand deaths from all causes, was as follows:

Under one year of service	87.7
From one to two years' service	30.9
From two to three years' service	25.9
From three to four years' service	8.6
Four years' service and upward	38.8

The causes of suicide in the German army may be roughly divided into one-third due to fear of punishment, one-half attributable to mental diseases and the remainder dependent upon disappointment from various causes and to dislike of the service.

In the Austrian army, the rate for self-destruction is high—being .97 in 1870, .81 in 1873 and 1.22 for the period of 1875–87. Suicide is relatively about four times more frequent in non-commissioned officers than in privates. Of late, the mortality from suicide represents 1.5 per cent. of the general mortality, and this rate appears to be increasing. As in the German army, more than half the suicides occur during the first year of service; and mutilations of the index finger, middle finger and thumb of the right hand—to incapacitate for military service—are common. One-third of the suicides are ascribed to dislike of the service, one-third to fear of punishment and one-third to melancholia. About 70 per cent. are accomplished by shooting and 20 per cent. by hanging. In the Italian army, 1874–89, the rate for suicide, per 1,000 strength, was .40. In 1888 it was .45 and in 1889 it was .38. Three-fourths of the cases are officially attributed to causes foreign to the military service. The rate for suicide was .24 in the Belgian army for the year 1891; in the Russian army it was .20 for the period 1879–89; in the Spanish army, for the year 1886, it was .14.

While it is obvious that all the causes of insanity and suicide among troops cannot be brought under official control, it is equally clear that the rejection or early elimination of those of unstable mental equilibrium, or with tendencies toward alcoholism, will do much to reduce the rates for these causes. This reduction is further assisted by short periods of enlistment, as is the case at present, and by tours of foreign service of not too long duration. While the unnecessary severity of discipline which is maintained in foreign armies does not obtain in our own service, it should not be forgotten that intelligent and just administration by superior officers will do much to promote the mental as well as the physical welfare of the men over whom they have been placed in power. The contented soldier has no leaning toward melancholia or to self-destruction.

CHAPTER XVIII.

THE HYGIENE OF HOT AND COLD CLIMATES.

General Consideration of Climate.—The primary cause of climate is the solar action—this being regulated by the distance from the equator, the angle at which the sun's rays strike the earth, the length of the day, and the degree of refraction which the rays undergo in their passage through the air. The secondary causes of climate are the elevation of the land, the influence of the sea, winds, rainfall, storms and moisture, the nature of the soil, the general and local inclination of the place, the configuration of surface, the amount of vegetation and extent of cultivation, the internal temperature of the earth, the purity and electrical state of the atmosphere.

According to Cullimore, the influence of temperature upon health, as shown by the relative duration of life in the different climatic zones, is as follows: From the equator to the 20th degree of latitude there is 1 death annually to each 25 inhabitants; from the 20th to the 50th degree of latitude, 1 death to 35; from the 40th to 60th degree of latitude, 1 death to 43; from the 60th to 80th degree of latitude 1 death in 50. In the north of France there is one death to each 43–44 inhabitants; in the south, 1 in each 40 of the population. Smith states, with reference to this point: "It is a well established fact that a temperature of 54° F. is best adapted to the public health, for at that temperature the decomposition of animal and vegetable matter is slight and normal temperature is easily maintained."

The influence of elevation of land is second only to that of the sun, as measured in degrees of latitude from the equator, in its effects upon the character of a climate, as it renders tolerable many regions in the torrid zone otherwise uninhabitable by the white race. Plains are subject to great difference in temperature between night and day, and plateaus to extremes of heat and moisture; but isolated, flat-topped hills and hilly districts are more equable. Mountain ranges exercise a marked influence on climate; their windward and rainy sides being often deluged with rain, while the country beyond is dry and protected. In passing over the summit of a mountain range, winds blow in a slanting direction down the leeward side, becoming drier and more heated as they descend. The distance at which they again reach the ground is said to average about seventy times the height of the range over which the wind has passed. The climate of valleys is influenced by the character of their inlets and outlets, their breadth and height, the slope and vegetation of the surrounding hills, the amount of sunshine which they enjoy, and the protection afforded from cold or hot winds. In broad valleys, the heat during the day may be great, owing to reflection from the mountain sides; while the nights are cool, owing to rapid radiation and to the movement down-

ward of cold currents of air from the hills. Narrow valleys are more equable as to temperature, but are apt to be damp, misty and lacking in sunshine.

The influence of the sea is next to that of elevation of the land in modifying climate. It is owing to the immense preponderance of water over land that the average temperature of the southern hemisphere is three degrees lower than the northern, that the climate of high seas is so cool and equable, that small tropical islands approaching in character to the climate of high seas are generally more healthful than larger ones, and may be more capable of colonization by the white race. In hot climates, the maritime regions are never as warm as the interior of the country at the same level, but in cold countries the reverse is the case. In cold climates, also, the temperature of the coast is often increased by warm ocean currents; while, on the other hand, cold currents also exist and lower the temperature of hot regions. The effect of the sea is thus to equalize temperature; the seasonal difference and that between day and night being less on the coast than at inland situations, while the relative humidity is generally great, and hot, dry and dusty winds rarely occur. The absence of cold winds depends mainly on the level character of the land. Marine climates are also cooler than those of other places at the same level, in consequence of the local wind, owing to the unequal heating of the land by day and night, while the greater humidity of the air helps to veil the rays of the sun. Water is heated more slowly, and gives off heat more slowly, than does land. It also retains it longer, and the loss by radiation is less than from land, while the air over it is more moist and equable than elsewhere. The specific heat of water is about five times that of earth; water cooled at the surface sinks, allowing a lighter and warmer stratum to come to the top—hence the adjacent layer of air is not cooled at night to the extent that it is on land.

Wind may be defined as the movement of the air, resulting from the difference in its temperature at various places. Heated air rises, and that which is of greater density flows in to supply its place. In their effects on health, winds are considered with reference to their velocity, temperature and the amount of dust or aqueous vapor they carry. The greater the rapidity of their movement, the more chilling and forcible their effect. Even hot winds, if dry, generally cool by promoting evaporation; but if moist they have proportionately little effect in lowering the temperature.

The rainfall depends on the prevailing winds, as regards their direction, temperature, moisture, velocity and electric state. Clouds deposit their contents either through the influence of cold or as the result of concussion or compression. Hence it is that the rainfall is greatest on the slopes of mountains, where a hot and moist air often first comes in contact with a cold one. Next to that on mountains, the rainfall is heaviest near the sea. The average amount of precipitation decreases from the equator to the poles; while as regards the number of rainy days, except in the vicinity of the equator itself, the reverse is the case. The rains are periodical in the tropics and the summer is the rainy season, while the greatest rainfall occurs in winter in sub-tropical regions. In temperate climates the rains occur throughout the year; but the heaviest fall is in autumn, when the warm sea-winds first meet the earth, which at this season is beginning to

grow cool. The rainfall on the slopes of hills increases with height up to great elevations; but at the altitude of ten thousand feet it is generally slight, snow usually taking its place. The so-called rainless regions, where the winds blow constantly toward the sea, are usually excessively hot and comprise the barren wastes known as deserts. Owing to their size, small islands of level character offer no obstruction to winds which blow over them, and the rainfall is similar to that of the surrounding seas; while forests, on the contrary, by offering a certain obstruction, cause an increased precipitation all around the coasts, with less in the interior—and this is in confirmation with the general effect of forests, which is to increase the precipitation of rain in the region surrounding them. While the principal source of moisture is the rainfall, rainy regions may be fairly dry as regards the state of the air, owing to the heat of the sun, the small number of wet days, the porous nature of the soil and, on mountains, the inferior capacity of the air for retaining moisture. On the other hand, the absence of rain is sometimes compatible with considerable atmospheric humidity, through the lack of condensing currents of cold air. Under such conditions, fogs and dews may supply to some extent the want of rain. The amount of moisture is represented by the degree of humidity, which is described as absolute and relative. The latter is more important from a climatic point of view. It represents the ratio between the amount of humidity in a given quantity of air and the amount the air can carry without the production of rain, and must be considered in connection with the temperature, the density of the air and its evaporating power, the latter being greater as the temperature is higher. It decreases with the ascent of mountains, is generally considerable over bodies of water, increases from the poles to the equator and is greatest of all in the tropics during the wet seasons. Moisture lessens evaporation from the skin and lungs, and, if the air is still, may help indirectly to increase temperature through its power of absorbing heat. If not accompanied by wind or rain, moist hot climates are more oppressive than the combination of heat and dryness. If the former conditions prevail, and the sky is overcast, the feeling even in hot countries is that of chilliness. Dry air is everywhere more bracing; moist air more soothing, enervating and more frequently showing its effects in loss of appetite, depression of spirits and disorders of the kidneys, stomach and bowels. Storms are felt to the greatest degree near the mountains and along the seashore—at the changes of the seasons they are most violent in the tropics and sometimes dangerous to the sickly. Atmospheric electricity probably exercises considerable influence on the human organism, but present imperfect knowledge does not justify any definite conclusions as to its effect.

A marked influence on the temperature and salubrity of a locality is exercised by its geological formation. In the tropics, it will generally be found that in places of moderate elevation the soil is composed of volcanic débris, covered with humus. This soil is comparatively healthy. In hot climates, a sandy soil is the most disagreeable of all; sand being not only easily heated but retaining a high temperature longer than any soil. The effect of cultivation and moderate afforestation is generally greatly to improve the climate of a place and to render it more equable. The temperature of the soil in forests is about twenty per cent. lower than that out-

side, and the mean annual temperature of the air ten per cent. lower. The day temperature is also lower, that of the night higher. The relative humidity is increased from three to ten per cent., and the rainfall is also greater. The air over grassy land is cooler and moister than over barren or sandy soil; while that over marshes is not only colder and damper than in other situations, but is generally saturated at night and morning with mist and fog. Drainage raises the temperature of the soil of arable and pasture-land; and the greater healthfulness of drained land is perhaps due, to some extent, to the soil-temperature being less subject to fluctuations.

As to climate, that of the equatorial belt is characterized by great equability, almost daily rains, cloudy skies and constant heat. The white race cannot become acclimated at lower levels near the equator; and the mountain resorts, unless very high and dry, afford no adequate change on account of the absence of seasons, the heavy rains and the excessive atmospheric rarefaction dependent upon the combined effects of heat and elevation.

In the tropical region extending from the equatorial belt to the 23rd degree of latitude, the hot and cold seasons become gradually more marked; until near the tropics, while the summer heat is intense, the cold of winter is perceptible and restorative. Here the hot and dry season is in the spring, the wet in summer and the cool in autumn and winter. In the dry, hot season—particularly in fairly dry climates—the heat before the rains is often almost intolerable, yet this period is perhaps the healthiest portion of the year. Like the equatorial belt, this region is characterized by marshes, jungles and great unhealthiness, especially for the white race and for new-comers. Some localities are rendered additionally insalubrious by the presence of malarial fevers, from which the drier regions are comparatively free.

In the sub-tropical division, the mean annual temperature is said to be eighteen degrees lower than that for the torrid zone. The variations are greater, and all the meteorological phenomena less uniform. Warm weather still predominates, yet there is a distinct winter and the seasons of spring and autumn begin to be apparent. When near the tropics, these regions are usually subject to the diseases of the torrid zone; but when well drained and cultivated, and lying toward the temperate regions, they are generally healthy.

Temperate climates are characterized by great variability as compared with the uniformity of the polar and tropical divisions. The fluctuations are frequent, and the mean annual oscillations of temperature vary from 40° to 70° F., depending greatly upon local conditions. The daily variations are also frequent, and all the seasons are distinct and nearly of equal duration. The spring and autumn, although agreeable, are the most unhealthy and the most subject to climatic disturbance. The winds are variable, while the rains, though less abundant and regular than in the tropics, are far more frequent and evenly distributed through the year. The rate of mortality is lower, and the longevity and intellectual and physical standard higher, than in warmer regions.

Cold climates, which represent the polar extremities of the great temperate zones, are characterized by a short but brilliant summer, and by a winter with snow on the ground between the months of October and May. The diurnal range, owing to the long duration of the summer sunny days

and to the slight influence of the sun in the winter, is remarkably slight, and contributes materially, in spite of the chilling mists and fogs, to that comparative freedom from chest affections which cold climates enjoy. Such climates are perhaps the healthiest of all.

Arctic regions are divided into the coast and inland ice districts. The climate is extremely cold, as the summer begins with July and ends with August. During this period, the sun remains continually above the horizon. Rain, sleet and snow occupy the spring and autumn. In addition to the intense cold, sudden changes are of frequent occurrence, summer sunshine giving place to fogs, mists and snow. The mean temperature of South Greenland is 33° F. At Upernavik, the mean of summer is said to be 58° F. and that of winter —7° F. Snow falls to the depth of twenty feet in certain localities. The climate is not unhealthy; the most common diseases being frost-bite, scurvy, the eruptive diseases, contagious skin affections and ophthalmia.

I.

THE HYGIENE OF HOT CLIMATES.

The physical elements of a tropical climate, ranged according to their hygienic importance, are humidity, heat and lack of variety. Humidity, in temperate regions, generally goes with cool weather, but within the tropics great heat prevails when loss of heat through evaporation of perspiration is retarded by a high degree of atmospheric moisture; dry heat, even if prolonged and of considerable degree, is by no means as unfavorable to the human organism. Everything which conduces to give variety to climate in the tropics affords relief. The alternating sea and land breezes of islands are potent forces in increasing their salubrity, and this is especially so when such islands are volcanic or mountainous.

Hot climates exert an unfavorable influence on new-comers through two conditions, those which are meteorological and those which result from endemic diseases—the latter being more directly dangerous. There is, however, ample proof that tropical heat and humidity produce marked changes in body-function which exert an effect adverse to the health and existence of all but the native-born. A brief consideration of these alterations of body function is important in connection with the consideration of various problems in tropical hygiene, particularly in relation to food and the processes of metabolism.

Physiology of Hot Climates.—The body-temperature in the tropics is appreciably elevated above the normal in new arrivals. Rattray, in his investigations upon this point, obtained the following results:

Hour of day.	Temperate climate, near England; temperature, 65° F.; average of ten days.	Tropics generally; average of fifty-one days.	Equator, temperature, 84° F.; average of seven days.
9 A.M	98.1°	98.51°	98.5°
3 P.M	98.3	99	99.5
9 P.M.	98.5	98.47	99.1
Average	98.3°	98.66°	99.02°

Maurel found an increase of body-heat in individuals recently arrived in the West Indies, ranging from .5° to .9° F.; and Jousset noted an average increase among the whites in Senegal of even greater degree. Fayrer states that among European residents in Bengal, the bodily temperature is .41° F. higher than the average of healthy persons in England. Careful observations made on Europeans between Khartoum and the equator showed that for those of less than two years' residence, the body-heat averaged 1° F. above normal; while among such as had been in that region longer than four years, the temperature was still half a degree above normal. These facts are interesting and important, and, as subsequently advanced, may explain the greater prevalence of disease in individuals undergoing the so-called process of acclimation. In temperate climates, animal-heat is readily lost by radiation and contact with the external air, by the heating of inspired air, by exhalation of moisture in the breath and by cutaneous evaporation. In the tropics, the difference between internal and external temperature is always very slight, and it may frequently happen that for considerable periods the heat of the surrounding atmosphere may even exceed that of the body. Further, the high degree of humidity ordinarily present in the tropics opposes evaporation of moisture. It therefore happens, through these changed conditions, that, instead of being concerned with the dissipation of heat, the vital forces must frequently neutralize heat-reception in order to keep the bodily temperature down to normal. This produces an alteration in metabolism and throws additional work on the kidneys and liver; for an excess of nutritive material, which in temperate climates would be oxidized in the production of heat, requires here to be merely excreted. Serious and unusual demands are thus made upon the excretory organs and their resistance is distinctly lowered—and in this state they are not infrequently called upon to eliminate the toxins of certain infectious diseases so common in some portions of the tropics that the stranger can scarcely hope entirely to escape them.

A loss of body-weight occurs in hot countries, and the same is commonly observed in summer in the temperate zone. Rattray noted that, with an average temperature of 80° F., the loss of weight among a body of British marines averaged eleven pounds per man during the period of one year. The decrease was greater when salt provisions were given and the air was loaded with moisture; the loss of weight when hard labor was required being even greater and more rapid. In the dry season forty-four per cent., and in the wet season seventy-six per cent., of the individuals observed by him lost in weight. Rattray concluded that this effect was due to the destructive influence of prolonged heat upon the cellular elements of the organism, together with imperfect oxygenation. Adipose tissue, as a non-conducting layer, is undoubtedly potent in conserving internal heat and diminishing the effect of outside low temperature. In cold regions, the proportion of fat normally present in the organism is much greater than in warm climates, where the storing up of fats in human tissue is rare, and even the artificial fattening of animals is accomplished with the greatest difficulty. In cold climates, on the contrary, considerable deposition of fatty material is the rule. The animal flesh of the far north, as seal, bear and walrus meat, is notoriously rich in fats; while the chief protection of the whale against the cold of the polar seas is the thick layer of blubber in which the muscular structure

is enveloped. Viewed from this standpoint, the decrease of body-fat which occurs in the tropics may be looked upon as one of the most important processes by which the adaptation of the organism to changed conditions of temperature, through better dissipation of body-heat, is accomplished. The discomfort of the obese during warm weather is proverbial; and hence loss of weight, provided the decrease is strictly limited to adipose tissue, may be regarded as wholly beneficial. It is obvious that any excess of food above the nutritive requirements of the organism, which in temperate climates is largely converted into systemic fat, cannot be devoted to this purpose in the tropics with either facility or advantage.

Tropical heat directly lowers the pulse-rate; Rattray finding that the average rate of cardiac action in the tropics was less by two and one-half beats per minute than in the temperate zone. The following results were obtained by him:

Hour.	Number of observations.	Tropics.				Temperate Zone.
		Lowest.	Highest.	Range.	Average.	Average.
9 A.M.	53	66	112	46	86.4	91.7
3 P.M.	53	68	108	42	88.8	88.1
9 P.M.	49	73	110	37	87.3	90.5
Average					87.5	90.1

This reduction of the pulse-rate is doubtless related to the diminished respiratory function; and further observation proves what the latter fact suggests—namely, that in the tropics the pulse is diminished not only in frequency but in force. The low arterial tension always noted in hot climates is a direct result of loss of fluid through increased perspiration, favored by a relaxed state of the capillaries.

The first effect of tropical heat is to increase the respiratory capacity. This has been shown by Rattray by means of the spirometer; his observations being subsequently confirmed by others. The results obtained by this investigator are as follows:

	Average capacity of chest in cubic inches.
Temperate zone near England, at sea—June. Thermometer 65° F. Hygrometer 2.5° F.	256.083
Tropics, at sea—July. Thermometer 78° F. Hygrometer 4° F.	280.75
Tropics, at sea—August. Thermometer 83° F. Hygrometer 4° F.	287.416
Temperate zone near England, at sea—September. Thermometer 65° F. Hygrometer 1.5° F.	260.25
Temperate zone, England—February. Thermometer 42° F. Hygrometer 3° F.	253.727

The average gain in lung-capacity noted by him for the tropics was 31.4163 cubic inches; the percentage of gain, as compared with the temperate zone, amounting to 12.24 per cent. Cullimore, however, states that this increase in lung-capacity does not continue, and that, after a period ranging from six months to two years, it falls below the level for Europe.

Closely allied to the foregoing is the influence of tropical climate on the frequency of respiration. In heated air-chambers, the rate of respiration becomes less in man, and Vierordt and Ludwig long since found that

the same results were obtained in animals subjected to great heat. Rattray's observations as to the comparative frequency of respirations in hot and cool climates are as follows:

		Average temperature (shade) F.	Highest number of respirations.	Lowest number of respirations.	Average number of respirations.
Temperate zone..	England in summer—June.	62°	18	13.5	15.68
	England in winter—February.	42.25°	17.5	15	16.5
Tropics.....	Equatorial doldrums, outward voyage.	78.74°	14.5	11	12.74
	Equatorial doldrums, return voyage.	78.6°	15	12	13.74

Not only is the respiratory action markedly decreased in hot climates, but the greater quantity of air taken in at each inspiration in the tropics does not make up for the diminished number of respirations in supplying the same amount of oxygen to the blood as in cold climates. Using the above data, Rattray calculated the deficiency in the oxygen inspired in the tropics to be as follows:

Climate.	Cubic inches in each inspiration.	Number of inspirations per minute.	Cubic inches respired.
England	15.000	17	255.000
Tropics	16.836	14	235.704

Difference in favor of a temperate climate, 19.296 cubic inches, or 7.567 per cent.

"This decrease of 7.567 per cent. in the quantity of air respired daily, diminishes the quantity of carbon which the lungs in ordinary circumstances can throw off in the tropics by .7567 ounce; 10 ounces being taken as the average amount thrown off in temperate climates will give 9.243 ounces as the amount for the tropics. But as tropical air contains less oxygen for a given bulk than air of colder latitudes, through the expansion of gases by heat, the decarbonizing capabilities of the lungs in tropical latitudes will evidently be still further curtailed and the amount of carbon they can throw off considerably decreased. Air increases by $\frac{1}{480}$ its volume for every Fahrenheit degree of heat, and the difference between the temperatures in which these experiments were carried on being 18° F. (65° and 83° F.), if we reduce the amount inspired in the tropics by a $\frac{18}{480}$ part, this will give its equivalent bulk in the temperate zone, thus:

$$\frac{235.704}{1+\frac{1}{480}\times 18}=\frac{255.704}{1.0375}=227.1846 \text{ cubic inches,}$$

which is equal to a decrease of 8.5194 cubic inches, or 3.614 per cent. Then 255 minus 227.1846 cubic inches give 27.8154 cubic inches per minute, or 1,668.924 cubic inches per hour, or 40,054.176 cubic inches per day = 10.907 per cent. as the grand total difference in favor of a temperate climate, after deducting the real increase in volume and correcting for expansion of heat. By again reducing the 9.243 ounces of carbon by 3.614 per cent., or .33409 ounce, we get 8.909 ounces as the total amount

which the lungs throw off in the tropics, the difference between the tropical and extra-tropical qualities being 1.1028 ounces."

The explanation of the variation in respiratory capacity, noted above, would appear to be due to the fact that there is no actual increase for the tropics in the size of the chest and enclosed lungs, but only an alteration in the relative proportion of blood and air contained in the latter. The bulk of the lungs remaining the same in the tropics as in cold latitudes, or being, as shown by Parkes, even somewhat diminished from their comparative abeyance as excreting and heat-generating organs, the blood, diverted to the functionally excited and congested skin and liver, permits the ingress of a larger quantity of air into the pulmonary air-cells.

With the diminution in arterial tension there is, also, at each respiratory movement, less blood forced through the lungs than in the temperate climate, and this diminution necessarily implies a lessened value to the respiratory act. Further, the air in the tropics is rarefied, and pressure, which rules the conditions of pulmonary endosmosis, is diminished; hence it may be that the air reaches the pulmonary alveoles under pressure insufficient properly to force it into the pulmonary capillaries. The deficiency of oxygen taken into the organism in the tropics, as influenced by the above factors, may therefore be considered to be made up approximately as follows:

Lessened value of respiratory act	7.5 per cent.
Rarefaction of air	3.6 "
Diminished cardiac action	3 "
Decreased air pressure	2.2 "
Total	16.3 "

It is undoubtedly true that less oxygen is required by the organism in the high temperatures of the tropics. Through decreased exertion, a smaller amount is required for the metamorphosis of waste particles, and, where lessened necessity and desire for food diminish the ingesta, less is required for direct combination with the nutritive elements in the production of energy. It is probable, however, that there is a somewhat increased absorption of oxygen in hot climates by the functionally excited skin, which may, to a slight degree, act vicariously as a respiratory organ and so lessen the amount required by the lungs. Furthermore, the skin is aided in relieving the lungs, in the decarbonizing process, by the functionally excited liver and kidneys, which eliminate carbon in forms which do not require much oxygen for their formation, namely, as bile and uric acid.

Where the blood does not obtain a proper supply of oxygen, its vital properties are diminished; a fact soon apparent in the deficient nutrition of the organism, and the depraved condition by which not only is liability to disease increased but also the probability of a fatal termination should disease occur. Deficient oxygenation, combined with heat, exerts a directly deteriorating influence on the blood corpuscles. Cullimore states that the blood corpuscles frequently diminish to as low as 3,000,000 per cubic millimeter after long sojourn in the tropics, and that the quantity of hæmoglobin is also much decreased. Every resident in the tropics early becomes anæmic; the heat often being assisted by malarial influences in deteriorating the function and diminishing the number of red blood corpuscles

The amount of sweat is greatly increased. Fonssagrives states that it is double the average amount secreted in Europe, often amounting to four or five pounds in the twenty-four hours. The amount of solids eliminated in this manner, however, is not proportionately increased. In addition, the secretion of sebum is more abundant than in temperate climates. In this connection, Hill says: "There are certain peculiarities in the natives of European countries that must strike the pathologist as intimately connected with the nature and treatment of diseases. These are chiefly the complexion of the skin, the large development of the respiratory and biliary, nervous and circulating organs, compared with the natives of intertropical countries. The skin of the dark races is not only different in color, but it is also considerably modified in texture, so as to enable it to perform a greater extent of function than the more delicately formed skin of the white variety of the species. The thick dark rete mucosum of the former is evidently more suited to the warm and moist climates of the tropics than that with which the latter variety is provided. The skin of the negro is a much more active organ of depuration than that of the white. It not merely exhales a larger proportion of aqueous fluid and carbonic acid from the blood, but it also elaborates a more unctuous secretion, which by its abundance and sensible properties evidently possesses a considerable influence in counteracting the heating effects of the sun's rays upon the body, and in carrying off the superabundant caloric. While the active functions thus tend to diminish the heat of the body and prevent its excessive increase by the temperature of the climate, the materials that require removal from the blood are eliminated by this surface, which in the negro especially performs excreting functions, very evidently in aid of those of respiration and of biliary secretion. In the white variety of the species, on the other hand, the functions of the lungs and liver are much more active than in the darker races, changes to a greater extent being performed by respiration in the former than the latter. The liver is also larger and its secretion more copious in the European than in the African or Asiatic." When the air is dry and in a highly electrical condition, skin action is greatly facilitated. It then becomes a refrigerating apparatus of remarkable power, being sufficient to protect the organism against the highest temperature.

As a result of increased perspiration, there is a diminished excretion of urine, the reduction amounting to about one-third of the usual amount in temperate climates. Mourson states that the diminution in the output of urea usually amounts to about ten or fifteen per cent. According to Eijkman, Europeans who had been in Java from two to six months excreted an average of 14.8 gm. of nitrogen daily, or .226 gm. per kilogram of body-weight, while those who had lived in the tropics one and one-half to fifteen years excreted an average of 12.802 gm. of nitrogen daily, or .193 gm. per kilogram of body-weight. Such decrease in eliminatory function on the part of the kidneys, according to Moore, is followed by increased secretory action of the liver, whereby some effete matter is passed into the intestines with the bile. But increased liver action is accompanied by congestion, and constant congestion frequently by hepatic deposit and degeneration, with impairment of function.

Through the loss of fluid resulting from increased perspiration, there is a diminution in the secretion of saliva, mucus, the gastric and pancreatic

juices and the bile. As a consequence, also, there is dryness of the throat and fauces and exaggeration of thirst, weakness of appetite, impaired digestion, gastric fullness after eating and habitual constipation; these, according to Nielly, being digestive phenomena constantly observed in the tropics. The increased loss of fluid causes a corresponding thirst, and the resulting increased ingestion of fluids by the new arrival is without doubt a cause for sickness, since it dilutes the gastric juice, impairs digestion and favors diarrhœa. In addition, the change of diet necessitated by residence in the tropics, together with the presence of unaccustomed forms of bacteria, is prone to cause a certain amount of gastro-intestinal disturbance even in the most careful individuals.

Upon the nervous system, a marked effect is exerted by heat and moisture, and a depression of vital and nervous energy is induced far exceeding that ordinarily observed in temperate climates. The brain suffers with the system in general—it would appear to more than its proper proportion. Certain it is that, in the tropics, persons even in fair bodily health find themselves, so far as intellectual work is concerned, at a very low ebb; soon wearied, fagged and unable to concentrate their ordinary amount of brain-power on any one subject. This diminution in capacity for mental labor is often followed by reduced powers of memory and is usually accompanied by nervousness and irritability.

Acclimation.—According to Rochoux, the process of acclimation consists in "a profound change in the organism, produced by a prolonged sojourn in a place where climate is widely different to that to which one is accustomed and which has the effect of rendering the individual who has been subjected to it similar in many respects to the natives of the country which he has adopted"—and Aitken, who quotes this observation, supplements it by saying: "The process takes place to a certain extent, so far as some individuals are concerned, but the ability to become acclimated is not possessed to the same extent by all nations."

That residence in hot climates, under the circumstances of ordinary life, has an adverse effect on the white race cannot be doubted. Some constitutions seem to be altogether unfitted for undergoing high temperature and great humidity, and such individuals lose their health and physical energy from the moment of their arrival in the tropics. A still larger number do so sooner or later under a more protracted residence, even if they escape being attacked by the endemic or epidemic diseases incidental to such climates—and hence the question of acclimation assumes great practical importance from the military standpoint.

As compared with whites, the African and Asiatic races possess a relative immunity to many diseases common in low latitudes, and an admixture of such blood confers an undoubted resistance to the prejudicial effects of a hot climate. It is a matter of common knowledge that the half-castes of such races, brought to the tropics, are often able to survive without difficulty in regions inimical to occupancy by white men. The fact seems to be well established that, among whites, Semitic peoples possess a power of acclimation or adaptability to tropical climates superior to that enjoyed by the Aryan races; and among the latter the inhabitants of southern countries—the Spaniards, Portuguese, Maltese and Sicilians—are superior in this respect to those of the north. Next to the Jews, the gyp-

sies are probably the most cosmopolitan. In the French expeditions in the tropics, the zouaves and troops with an admixture of Arab blood and—in less degree—the troops coming from southern France, have suffered less from typhoid and other forms of fever than have those from the north. The Anglo-Saxon branch of the Teutonic stock is severely handicapped by nature in the struggle to colonize the tropics; and Ripley gives the following table as showing the relative disabilities of Europeans in Algeria, on this point, for the years 1855–56.

	Births per 1,000 population.	Deaths per 1,000 population.
Spaniards	46	30
Maltese	44	30
Italians	39	28
French	41	43
Germans	31	56

It is not at all easy to say, however, how much of the excess of mortality of Europeans in tropical and sub-tropical countries, over that of the natives, is simply attributable to climate *per se* and is consequently inevitable, or how much of it is the direct consequence of unsuitable habits of life and of the neglect of sanitary laws and of personal hygiene. It may be said, in general, that the only real acclimation in warm countries is that which enables the white race to enjoy health equal to that of the natives, while constantly performing hard manual labor in the open air—and this is not considered possible by most authorities. It cannot be denied that the Spanish nation—in which, it should be mentioned, there is a considerable element of Moorish blood—has met with a certain degree of success in colonizing tropical countries; but this has not been as an agricultural class, and it is none the less true that it is the only white nation which has succeeded to any degree in establishing a foothold in the tropics. In India, it is an axiom that English stock cannot exist beyond the third generation.

The new arrival in the tropics is usually condemned to undergo certain diseases prevalent in such climates, and if these are not fatal a certain degree of tolerance to altered atmospheric or other influences, in a fair proportion of cases, is undoubtedly acquired; but that this latter class, at any portion of its existence, possesses the immunity to tropical disease which is so marked a characteristic of the natives must be denied. The attempt at the acclimation of the white race in the torrid zone is a procedure fraught with difficulty and danger and is usually compromised by unfavorable endemic influences. Experiment has demonstrated that in animals there is a definite connection between an elevated body temperature and the liability to disease of an infectious character. Whether this accounts for the greater susceptibility to disease existing in unacclimated individuals in the tropics is an open question; but it is certain that strangers are most liable to sickness during the period immediately following their arrival, when their temperature is above the native normal. As far back as 1788, Hunter wrote: "Those who are just arrived from cool and healthy climates are particularly subject to fevers, as is daily experienced by all new-comers. A regiment always loses a greater proportion of men in the first year than afterward, supposing their fitness to be the same." This point is well illus-

trated by Marston in the following table, showing the death rate of British white troops in India, per thousand of each class, for different periods of residence in that country, based upon statisics for the period 1877–84.

Year.	First and second years of service.	Third to sixth years of service, inclusive.	Seventh to tenth years of service, inclusive.
1877	3.31	1.35	0.90
1878	7.90	2.64	1.38
1879	7.99	2.18	1.24
1880	9.08	1.78	.47
1881	4.55	2.07	.56
1882	4.68	1.93	.34
1883	4.98	1.55	.55
1884	5.47	1.55	.46

All authorities agree that the regions of the tropics where acclimation of the white race is most difficult of accomplishment are to be found in the areas of excessive humidity. Hence any alleged successful examples of tropical colonization should always be examined in the light of this condition. Wherever there are perceptible seasons of heat and cold, the adjustment of the organism of the foreigner to a new environment is more readily accomplished; and this is one advantage of the climate of tropical plateaus, where both daily and seasonal variations of temperature are comparatively great.

It has repeatedly been demonstrated that most attempts at gradual acclimation are futile, except as regards the season for arrival, and do not serve to protect against the endemic diseases of the tropics; particularly in the case of malaria there being no such thing as an acquired immunity. It is best, therefore, to send troops direct to their post of duty from a temperate station. Where new troops are destined for an extremely unhealthful locality they may, however, on landing, be sent for a brief period to a high and salubrious station to become partially accustomed to new conditions of climate and environment.

Composition of Military Forces.—From what has just been said, it is evident that troops detailed to the tropics should, for the United States service, be as far as possible recruited in the southern states, and particularly from those bordering on the Gulf of Mexico. A large proportion of such forces will with advantage be recruited from the negro population of these warmer districts—it being well demonstrated that the negro enlisted from the northern states has, through his environment, largely lost his racial insusceptibility to typhoid, malarial and yellow fevers. It will also be of the utmost advantage to organize a considerable proportion of the troops required for colonial service from the acclimated natives of the region within which military forces must be maintained. This policy is largely employed by England, France and Germany; the French colonial forces being said to be made up of 18,000 white troops and 16,000 natives. In the British military service, the native troops serving in the tropics are about two and one-half times greater in number than the Europeans; and in the most unhealthful colonies, the proportion of native soldiers is four, five or—as in Sierra Leone—six times greater than that of the white troops. This example should be followed in our own service and there should certainly be

a sufficient native force to garrison the more unsalubrious stations; the recent organization of native regiments in the Philippines and in Porto Rico being of much advantage. Such native troops escape much of the sickness which must be regarded as inevitably attaching to foreign forces, as has already been shown in connection with the diseases of the soldier, and hence their constant rate of effectiveness is higher. Concerning this point, Lemure writes: "During the active period of (French) operations in Dahomey, August to December, 1892, the rate of deaths from disease among the European troops was 111 per 1,000; among the natives 15.1 per 1,000."

Speaking broadly, the nearer in physical type, temperament and complexion the soldiers detailed for tropical service approach to the natives of such climates in these respects, the more likely they are to stand the climate and to prove healthier than fair-skinned men of larger stature—who, on the other hand, are far better adapted for hard and arduous work and supreme physical effort in cold or temperate regions. For service in hot climates, men of medium stature, spare frame, dark hair and complexion, and thick skins may be expected to retain their health and to make the more enduring and efficient soldiers. It is of importance that only those should be selected for such service as show no signs of actual or latent disease, have become accustomed to the conditions of the military life, and are seasoned, mature and well developed. The filling up of regiments in the tropics with untrained and youthful recruits is a mistaken and wasteful policy; and all recruits should be re-examined before embarkation with respect to their fitness for tropical service. In the French colonial service, only those men are permitted to take the field who have attained the age of twenty-two years, have been one year in the service and are of robust constitution and full-blooded habit. The commander-in-chief of the British forces in India, in 1876, officially expressed his belief that the soldier was at his best, for duty in that country, at the age of twenty-seven to thirty years of age and after five years' residence in India; the adjutant-general being of the opinion that the British soldier was most fit for tropical service at the age of twenty-seven years. No soldier was accepted for the British Ashanti expedition, in 1895, who was not at least twenty-three years of age and had not had as much as three years' previous military service. The vast importance of age and previous service in relation to sickness and mortality in the tropics has also been brought out in previous chapters, and it may be accepted as being most undesirable to send recruits under the age of twenty-four years to stations in the low latitudes.

It is important that troops to be sent to the tropics should consist of well-disciplined and not newly raised men, for the latter, being less orderly and discreet and not accustomed to the life of the soldier, suffer far more from the climatic and environmental conditions than those habituated to discipline and control. In addition, it is extremely difficult properly to drill and instruct men in a climate where there are so many opposing conditions to be encountered and where the great heat renders it impossible to exercise in the open air except for a short time in the morning or evening.

Season for Arrival.—This is a matter of much importance, and the military history of every colonizing nation shows illustrations of the grave consequences which have followed neglect in this respect. In the British expeditions on the west coast of Africa, prior to 1873, the re-

sults were uniformly disastrous and the sickness and mortality little short of appalling. In the Ashanti expedition of that year, however, the operations were strictly limited to the healthy season and the sickness and loss of life attained only insignificant proportions. The rainy season is much more dangerous to the unacclimated, and it is advisable, where prolonged residence in the tropics is anticipated, that the organism be in a certain degree prepared for the arrival of this season by a previous existence of several months under the new conditions. By such an arrangement, the suddenness of transition from a healthy climate to the most sickly season of an insalubrious one is avoided, the clothing and diet are more gradually modified, the system has a better opportunity to accommodate itself to a change of function, and the unhealthful season, when it does come, is met by constitutions modified to such extent as to have lost something of their impressibility to endemic causes of disease. Hence, time spent in delaying the embarkation of troops to a more favorable moment is not lost, but will be more than compensated for by time saved from restrained methods of life or perhaps confinement to bed during acclimation in an unfavorable season. England and Germany have issued formal advice to intending colonists in respect to the time for arrival, and do not, except from urgent necessity, send civil or military officials to the tropics during the rainy season. This is a rational precaution which should be carefully observed in our own service, and, as far as possible, all movements of troops to the tropics should be so timed as to result in their arrival during the months of December and January.

Food.—With respect to the quantity of food necessary to the maintenance of health and vigor in the tropics, it may be premised at the outset that this is less than would be required in colder climates, provided that the amount of external muscular work to be performed is the same in both instances. In considering the question of tropical dietaries, the fact that food gives rise to both heat and energy, when taken into the system, is too often overlooked. These, within certain limits, are complementary and vary inversely with each other—but the material from which both have their origin is fixed in quantity and has a definite chemical composition. A given amount of nutritive material has thus a positive potential value; it will give rise to a variable amount of animal warmth and will permit the accomplishment of a variable quantity of external muscular work, but the sum of the two will never be greater than the caloric value of the quantity of food from which both were derived. Force and heat cannot be created from nothing. On the other hand, a portion of the food ingested may be excreted unused without passing into the system; or if it be digested and absorbed it may not at once be utilized, in which case the excess is stored up as fat within the organism, and becomes a reserve supply of heat-generating and force-producing material which can subsequently be drawn upon as the needs of the system may require. It is evident that in the tropics, from the high external temperature, little food is required to maintain the proper degree of animal warmth, and that the chief problem relates to the dissipation of such body-heat as may be produced beyond the needs of the system—as evidenced by the abnormally high bodily temperature noted in new arrivals in the tropics. Hence, if the external muscular work done in the tropics is the same as in colder climates, the difference

in the quantities of food required in both cases, over and above the amount necessary for the production of the energy needed in the performance of this fixed amount of work, will vary with the difference between the body-temperature and the temperature of the surrounding air. More food is obviously required for the maintenance of normal body-temperature when the surrounding air has a temperature of, say, 40° F. than when the latter is heated up to 85° F.

It is true that, with the same diet, an excess of nutritive material not required for purposes of warmth or repair, if not stored up within the organism, might be used in the creation of energy, and thus would be available for the accomplishment of more work than would be possible in colder climates, where a larger proportion of the food must be devoted to the production of body-heat; but in practice this is not the case, no greater amount of work can be accomplished by the individual in the tropics—in fact, experience shows that even less is possible—and the storage or elimination of an unused excess of food, for the reasons previously detailed, is undesirable. These points can be illustrated by supposing a furnace having two steam boilers, one being used for the supply of steam necessary in heating a building during winter, while the steam in the other boiler furnishes motive power by which work is performed. By the combustion in a given time of a definite quantity of coal in this furnace, a definite quantity of energy is liberated which is variously manifested as heat used in warming the building or power for the performance of work, but the sum total of heat and work can equal only the energy latent in the fixed quantity of fuel consumed during the given period. If the weather so moderate as to allow great reduction or even the discontinuance of the operation of the steam-heating apparatus, it is evident that the fixed quantity of fuel is capable, through its combustion, of supplying additional energy manifesting itself as an increase in motive power by which more work can be performed. But if an increase in the work done cannot be accomplished by reason of the limits of strength of the operating machinery, if it cannot be run either at greater speed or for longer hours, it is obvious that this additional supply of available energy cannot be utilized to advantage, and if the full amount of coal be actually consumed, the excess of steam produced must be discharged and let go to waste.

The amount of food required by the human organism thus depends upon two factors, the work to be done and the animal heat to be created—and these cannot be properly considered except in relation with each other. Hence, under exhausting labors and fatigues, with corresponding wear and tear of the muscular system, in the tropics as well as in cooler climates, a liberal supply of food is required in the production of energy and repair of systemic losses, and this is used by the soldier, under such circumstances, with satisfaction and advantage. On the other hand, both theoretical considerations and practical experience go to show that soldiers need less food than is ordinarily required in temperate climates, and at first are prone to eat too much, particularly of nitrogenous and fatty matter. Ultimately, however, after a sojourn of varying length in the tropics, want of appetite —nature's provision against excess—intervenes to diminish the dangers of over-eating.

With respect to the quantity of food required in the tropics, it should

be remembered that both the digestive and assimilative functions are impaired under the influence of prolonged heat. Hence, work should not be imposed upon the alimentary tract in excess of its powers and the diet should be restricted as compared with that of temperate climates; particularly since both diarrhœa and dysentery are known to be favored by the presence of a large amount of undigested food in the intestine, while tropical anæmia may be hastened by mal-assimilation resulting from overtaxation of the digestive processes. The respiration, as has already been shown, is much less energetic after arrival in the tropics, and this, combined with the rarefaction of the atmosphere and other factors, results in a much less amount of oxygen being introduced into the organism than is the case in temperate climates. If this reduced quantity of oxygen finds in the organism an excess of alimentary substances, it is evident that the oxidation of the latter will be delayed even if ultimately complete, and the equilibrium of nutrition is thus impaired. It may fairly be assumed that the decrease in the quantity of carbon which the lungs can throw off in the tropics, amounting, as has been shown, to probably about sixteen per cent., is an indication for the regulation of the diet as to kind and its corresponding reduction as to quantity. Further, according to Foster, the amount of heat evolved by the internal organs depends largely on their stimulation. In the case of the salivary glands, the temperature of the saliva during irritation of the chorda has been found to be 1° to 1.5° higher than that of the blood in the carotid artery at the same time; and he states that, in all probability, the investigation of other secreting glandular organs under excitement would yield similar results. Particularly is this true of the liver—an organ in which a large amount of heat is produced, as is shown by the fact that a temperature of 40.73° C. has been observed in the hepatic vein, while that of the right heart was 37.7° C. and that of the inferior vena cava 38.35° C. Hence, the excitation of the liver, through either the improper selection of foods or an excess of nutritive material requiring disposal, is to be avoided in hot climates. It is obvious that the consumption of an excess of food for the production of internal heat is here as unnecessary as it is undesirable; while the nutritive needs of the organism require a smaller amount of material to repair the systemic losses resulting from the usually less active life of the tropics.

On the other hand, the conservation of the appetite to a reasonable extent, when seriously impaired by the effects of prolonged heat, is desirable in the diminution of anæmia and probably in the liability to malarial and other infectious diseases. To maintain a sufficient desire for food, the diet and its preparation should be frequently varied. The meager breakfast which suffices the native of the tropics, usually merely a cup of black coffee and a bit of bread, does not meet the wants of the United States soldier in hot countries. The morning repast should be light, however, and by no means as substantial as is required in colder climates. Under no circumstances should the work of the day be begun until the appetite is moderately satisfied. Troops should be served with breakfast at about six o'clock, while dinner, the heavy meal of the day, should be taken about 11:30 o'clock. Supper should be light and should be served at about 5:30 in the afternoon. Food should not be eaten between meals, nor should articles of food be brought into the barracks. The

purchase by the men of food from native sources should be discouraged; this is particularly important during campaign, and during the last Ashanti expedition the British soldiers were not permitted to use food outside that officially provided.

Nothing is more certain than that the character of the diet should vary with the climate; a fact too frequently ignored by whites sojourning in the tropics. In selecting the food for such climates, care should naturally be taken to use but slightly those substances which go so largely to the production of animal heat; since the dissipation of the latter, for the reasons already enumerated, is but poorly accomplished. In character, the food should be plain and simple, readily digestible and nourishing without being too stimulating. While careful regulation of the food-supply is thus necessary, it is not expedient to imitate the natives of the tropics too closely in the special character of the articles of their diet, although it is none the less true that the food of the foreigner should possess such nutritive elements as, when taken together, would approach their dietary standards. Habit, in the selection of articles of food, is to a certain degree hereditary, and the digestive machinery is not adapted to excessive or too sudden changes. Considerable modification of the ordinary dietary is certainly necessary—not only in the interests of a lessened heat-production, but also so as not seriously to impair the digestive powers—but these changes do not necessarily require any modification in the character of the articles of the ration as at present supplied. The best diet for the tropics does not depend upon the use or disuse of any particular food-stuffs, as rice or bacon, but has relation merely to the proportion in which the proximate principles exist in the daily dietary, as expressed in terms of Calories and grams of fat, protein and carbohydrates. Rice is the chief article of diet among the inhabitants of the tropics, and is eaten in large quantities. The new-comer, however, cannot properly digest such a bulky diet; and even the natives are compelled to excite gastric secretion by the free use of peppers and other condiments, which, in large quantities, in the unaccustomed stomach of the foreigner, may tend to produce intestinal catarrh and indigestion.

Vegetables should form a large part of the food provided for troops; but care should be taken that they are always of good quality, and are fresh and properly cooked. Possessing a comparatively low nutritive value, the desired distention of the stomach should be given by foods of this class, and by their use constipation is largely prevented. In respect to their selection, reliance can safely be had upon the vegetable material at hand so abundantly provided by nature for human consumption. Rice is readily digested, but should be used by the foreigner only in connection with other foods; and the same applies to yams, sweet potatoes and other tropical vegetables. The latter, being obtained fresh, may frequently be issued with advantage in place of vegetables transported from temperate climates, which deteriorate rapidly on arrival. Dry leguminous foods, as beans, peas and lentils, are highly nitrogenous, yet are less readily digested than meats. They should be used sparingly, and preferably in soups rather than any other form. They must be well cooked, as they are not otherwise acted on with advantage by the digestive juices. The use of raw vegetables, in salads, is not desirable for troops in the tropics, as favoring diarrhœa and dysentery; and during

the prevalence of diseases affecting the alimentary tract their use should be prohibited. A diet chiefly vegetable has been thought by some to favor the occurrence of tropical anæmia, but such objection is purely theoretical and not supported by facts. The Brahmins of India are strictly vegetarian in their diet, yet their freedom from disease, their physical powers and expectation of life are said to be fully as great as those of the other native classes in contact with which they live.

A vegetable diet in the tropics is soon craved by all, and if this be not supplied, soldiers will have recourse to native fruits, often to excess. Ripe fruit plucked directly from the tree is usually wholesome; but when handled by dirty and possibly diseased natives, placed in filthy receptacles and stored temporarily in possibly infected places, it becomes a potent factor in the production of disease. This is especially the case with pineapples and such other fruits as are ordinarily peeled by the native vendors and exposed for sale in this condition to the sun, dust and flies. The danger in the use of fruit in the tropics is not so much due to its possession of any inherent deleterious qualities as it is to its frequent contamination with pathogenic bacteria before consumption. Oranges are particularly agreeable and beneficial and may be taken freely. Bananas should be used somewhat sparingly as being liable to produce indigestion and diarrhœa, and, like plantains, should preferably be taken cooked according to the native custom. Pineapples are not readily digested and should not be used in excess. Mangoes are much used by the natives as food. They are popularly supposed in India to give rise to boils, and in tropical America to produce yellow fever; apparently because these affections are most prevalent at a season when the mango is ripe, or shortly afterward. Cocoanuts, sapodillas, sugar-apples, mammey-apples, and other fruits may be used raw in moderation; but where its nature permits, such fruit is stewed with advantage. While fruit should habitually be used as a laxative in overcoming the constipating effect of climate, it should be remembered that its excessive consumption by the stranger is certain to be followed by intestinal disturbance. It is scarcely necessary to say that new arrivals will do well to be cautious in this respect, until they know what best agrees with them among those fruits with which they have no previous acquaintance.

Those who have been accustomed in the temperate zone to much animal food, or, in other words, to a highly nitrogenous diet, have also generally been accustomed to a large amount of bodily exercise, and by this means have been able to maintain a healthy metabolic equilibrium. Unfortunately, however, the same amount of exercise will not ordinarily be secured with comfort or safety in very hot climates, especially by new-comers; and thus the need for food of this character is greatly diminished. Meats should thus be taken in moderation, and regulated in quantity according to the repast. The use of flesh at all three meals is undesirable; and it should not be eaten, except as soup or flavoring, more than twice in the twenty-four hours. When used, it should be carefully prepared and well cooked, and should present its nutritive principles to the economy in a form readily assimilable and adapted to repair the losses of the organism, without leaving any excess of undigested refuse to irritate an overloaded and atonic alimentary tract. Soups, stews and rare roasts are hence to be preferred, and

boiled or fried meats should be avoided. In hot countries, native meat, as a rule, is not tender in consequence of the necessity of cooking it within a short time after slaughtering; and for this reason imported refrigerated meats are superior to the native article. In the tropics, beef is the standard animal food, but mutton is excellent if it can be procured. Pork is undesirable from its greasy, heavy and indigestible character. Native swine are largely feeders on filth and offal and their use as food should always be avoided. Chickens and eggs are excellent, but can scarcely be considered as normal constituents of the diet of the soldier. Fish, either fresh or salted, is of great value as not being a concentrated food and should be much used. Canned meats should never be employed where the fresh article is available; and, when used, must be eaten within twelve hours after the can is opened.

English authorities are united in their condemnation of all highly spiced and peppery dishes in the tropics, on the ground that they are largely responsible for the derangement of hepatic function so often seen, and that they produce congestion and irritation of the digestive organs. These conclusions would seem to be illogical. Chili, curry, soy and other carminatives, in considerable quantity, are apparently a necessity in securing the proper digestion of the bulky foods used by the natives of hot countries, and it is particularly noticeable that liver disease and disorders of digestion are infrequent in this native class. Hence the ill effects usually considered by foreigners as due to the high seasoning of the native cookery will probably be more justly attributed to their own almost universal use of a too rich, greasy and nitrogenous diet, unsuited to the climate.

The Tropical Dietary.—While the army ration, in constituents and quantity, is established by regulations, the actual diet of the soldier, within certain limits, is what the company commander and his first sergeant and cook may choose to make it. It has already been stated that the tropical dietary is a matter of proximate nutrient principles and fuel value and not one of the use or avoidance of any special articles of food, and hence the present established ration contains within itself all the elements of a suitable dietary for the tropics. There is, however, a best nutrient standard to which the food of the soldier serving in hot climates, particularly when performing the ordinary routine of garrison duty, should approximate in its chemical constituents and potentiality with regard to the production of heat and performance of work. What this approximate dietary standard should be, it is the purpose of this section to indicate.

Various attempts have been made by physiologists and chemists to devise standards representing the amount of nutrients required, under varying conditions, for daily sustenance. There are; however, two great difficulties in the way of setting up such standards. The first is that there is not sufficient definite knowledge on the subject of nutrition to permit of an exact statement as to how much the average man, doing a certain class of work, requires for the maintenance of his body in vigorous condition and for the creation of energy expended in the form of heat and work. The second difficulty depends upon the fact that different individuals of the same class, under the same conditions, differ widely in their demands for food and the use they make of it. One will eat more and the other less, while both do the same amount of work; or both will eat the same

food and do the same amount of work, yet one will be fat and the other lean; or both have the same diet, yet one will be strong and capable of performing considerable work while the other will be weak and able to accomplish little. Exactly why individuals differ in their ways of utilizing their food, and how to measure these differences and make rules to fit them exactly, are problems which are as yet far from solution. The nutrition of man is by no means merely a question of grams of protein and units of energy, and hence the subject of dietetics can never be reduced to an exact science. The best that can be done is to make general estimates, with the understanding that such estimates are only approximately correct, even for a special class. These are reached by observing the amount and relative proportions of the food actually consumed by the individuals composing the class in question, and also by experiments in which the income and outgo of the body are directly compared. But little investigation has as yet been done by the latter method, and present knowledge of nutrition may be considered as based entirely upon observation and analysis of established dietaries, which have been shown by experience to possess sufficient reparative and potential value for the special conditions under which they are used. For present purposes, these dietaries should cover not only varying conditions of external muscular work but also of climate, so that comparison in the latter respect may be possible.

For determining the diet of the soldier, it is necessary to refer to the dietaries of men at hard labor in various portions of the temperate zone and in the tropics; the following table being intentionally made to include dietaries of this character for different countries in the northern portion of the temperate zone, since the United States army is heterogeneous in its composition, and the foreign-born element—largely drawn from the countries named—undoubtedly brings with it into the military service the dietetic preferences resulting from previous habit:

TYPICAL HARD-LABOR DIETARIES FOR THE NORTHERN PORTION OF THE TEMPERATE ZONE.

	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutritive ratio (protein to energy).
England — Royal engineers, active work. (Playfair.)	144	83	631	3,950	23.04	1:5.7
Sweden—Mechanics. (Hultgren and Landergren.)	189	110	714	4,725	30.24	1:5.1
Russia—Factory operatives, near Moscow. (Erismann)	132	80	584	3,680	21.11	1:5.8
Germany—Machinists, Krupp gun works. (Prausnitz.)	139	113	677	4,395	22.24	1:6.7
Southern Austria—Farm laborers, at harvesting. (Ohlmüller.)	159	62	977	5,235	25.44	1:7
United States—Mechanics, Massachusetts and Connecticut. (Atwater.)	154	227	626	5,275	24.64	1:7.5
United States navy ration. (Atwater.)	143	184	520	5,000	22.88	1:6.8
United States army ration	164.2	97.8	600	4,061	25.33	1:5
Average	152	119.5	666	4,540	24.36	1:6.2

Total carbon 463.89 gm.; nitrogen to carbon 1:19.4.

As compared with the United States army ration, included in the above table, the average of these dietaries is seen to be slightly in excess in fats, carbohydrates and fuel value, but deficient in protein. On the whole, however, the difference is not great, and the sufficiency in amount and proper proportion of the food provided for the soldier serving in a more northern portion of this country is abundantly demonstrated.

In the warmer portions of the temperate zone, but still well outside the tropics, the quantities of the several proximate principles required by the inhabitants are markedly inferior to the figures above given. The dietaries of these regions have not been as thoroughly studied as in countries lying in a cooler climate, but the following data are sufficiently comprehensive to be of both interest and practical importance:

TYPICAL WORKING DIETS OF THE SOUTHERN PORTION OF THE TEMPERATE ZONE.

	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutritive ratio (protein to energy).
Italy—Mechanics. (Manfredi.)	76	38	396	2,290	10.55	1: 6.3
Italy—Army ration, peace. (Moleschott)	114	14	592	3,095	18.24	1: 5.5
Japan—Prisoners at work, Tokyo. (Eijkman)	66	9	544	2,585	10.66	1: 8.5
United States Mexican, New Mexico, families. (Goss.)	68	73	572	3,320	10.88	1: 8.3
United States Negro—Southern Gulf States, families. (Atwater and Woods)	62	132	436	3,270	9.90	1:11.8
Average	77	53.4	508	3,012	10.72	1: 8

These figures, however, are based upon races, with the exception of the United States negro, of less body-weight than those of colder climates, and hence are not properly comparable with similar figures for the latter class until reduced to a common standard in this respect; since, according to Church, the capacity for muscular work may be considered as closely related to body-weight. If it be assumed that laborers in the southern portion of the temperate zone have an average weight of 125 pounds, while the corresponding class in the cooler part of the same zone have an average weight of 145 pounds—about that given by statistics as the mean weight of recruits for the United States army—the above average figures should be corrected as follows:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutritive ratio (protein to energy).
89.3	61.94	589.28	3,493	14.3	1:8

Total carbon, 354.73 gm.; nitrogen to carbon, 1:24.8

While the foods habitually used by natives of the tropics are well known to differ widely in character from those employed in temperate climates, and while the existence of a certain deficiency in the native dietary in the matter of protein and fats has long been recognized, there has been but little investigation as to the force-value of the tropical dietary or to the exact qualities and relative proportions of the several proximate prin-

ciples entering into its composition. The question of tropical dietaries has, however, been locally studied by Maurel, in the island of Guadeloupe, by Church, in British India, by Eijkman, in Java, and by Lapicque, in Abyssinia. The results obtained by these investigators in diverse portions of the tropical zone, although but few in number, nevertheless agree so closely in all respects that they may be accepted as conclusive and their average as fairly representing the nutrient standard of the laboring class of natives throughout the tropics. The average chemical composition of the four dietaries investigated by these observers is as follows:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutritive ratio (protein to energy.)
60.21	31.8	442.2	2,300	9.63	1:8.8

For purposes of comparison, however, these figures, like those for the inhabitants of the warmer portions of the temperate zone, must be reduced to the common standard of body-weight of 145 pounds—the average weight of laborers in the undersized races of the tropics being assumed to be about 115 pounds—and the above figures are thus proportionately increased, as shown in the following table:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutritive ratio (protein to energy).
76.18	40	560.01	2,900	12.18	1:8.8

Total carbon, 318.13 gm.; nitrogen to carbon, 1:26.1.

On contrasting the several dietaries which have been shown to obtain with men having an average weight of 145 pounds, engaged at hard muscular labor, in the northern portion of the temperate zone, the southern portion of the temperate zone and in the tropics, the difference in the quantity and character of food taken is seen to be most marked, particularly in relation to the protein and fats. The difference in force-value between these dietaries is also very great, and even the use of carbohydrates, contrary to usual ideas, is also diminished in the tropics. These typical dietaries are shown in the following table:

Climate.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Nutrient ratio (protein to energy).	Carbon, grams.	Relation of nitrogen to carbon.
Northern portion of temperate zone	152	119.5	666	4,540	24.36	1:6.2	463.89	1:19.4
Southern portion of temperate zone	89.3	61.9	589.2	3,493	14.3	1:8	354.73	1:24.8
Tropics	76.18	40	560	2,900	12.18	1:8.8	316.13	1:26.1

It may, however, be urged that the marked variation in the composition and force-value apparent in the above dietaries is due rather to racial preference than to climatic influence. This claim would scarcely appear to be well founded. It is a matter of common observation that natives of the tropics removed to colder climates soon adopt the dietetic customs

of the region in which they may be resident. Further, it should be noted that Atwater and Woods showed the average daily consumption of food in twenty negro families in the rural districts of southern Alabama to consist of 62 gm. of protein, 132 gm. of fats and 436 gm. of carbohydrates, and to possess a force-value of 3,012 Calories; while Frissell and Bevier found that the average dietary of nineteen negro families of the same class, resident in northern Virginia, yielded 109 gm. of protein, 159 gm. of fats and 444 gm. of carbohydrates—with a force-value of 3,745 Calories. It is idle to assume that this great difference in the composition and nutrient value of the dietaries for corresponding classes of the same race, resident in different latitudes, can be dependent upon other than climatic conditions. Hence it may be assumed that the food of human beings, both in relative proportion and nutrient quality, varies directly with temperature, as approximately expressed by latitude.

The standard dietaries having been established for laboring men performing hard work under diverse climatic conditions, it becomes necessary to examine the present United States army ration with a view of ascertaining the nutritive value of its several components, and determining whether the quantities in which their issue is authorized will permit their combination in a daily allowance, not only desirable in theory and well qualified to maintain the health and vigor of the soldier but also thoroughly practicable under all conditions of military service.

On referring to the four combinations of the articles of the ration given on pages 162 and 163, it is seen that the first combination, as compared with the average dietary for individuals of the same weight native to the tropics, presents a great excess in protein, fats and fuel value—even the carbohydrates being largely increased. In the second arrangement, the fats are present in five times the quantity apparently sufficient and desirable under tropical standards, the protein is in considerable excess and the fuel-value unnecessarily high, while the deficiency in carbohydrates is noticeable. In the third dietary, the fats and protein are both in excess, but the quantity of carbohydrates is markedly deficient. The force-value of this combination is probably not far from the actual requirements of the system, in the tropics, as regards energy. In the last arrangement of the articles of the ration, the protein is seen to be present in slight excess, while the fats and carbohydrates are markedly deficient, the former especially so. The force-value of this dietary, also, is insufficient to meet the needs of even moderate muscular labor. The conclusion is therefore justifiable that while the several articles composing the ration are well selected, the maximum quantities in which their issue is now authorized are so proportioned that their combination in a dietary, approximately similar to the nutrient standard of native laborers in the tropics—even under conditions of equality as regards weight—is practically impossible. It is therefore desirable that the company commander should use only such quantities of these ration components as would permit of proper dietary requirements for tropical service, as based upon the amounts of protein, fats and carbohydrates desirable for the daily dietary.

With respect to the quantity of proteid required, the proteid molecule, as shown by Krukenberg, Pavy, Schützenberger and others, is not to be regarded as a perfect chemical body, but as a complex, composite mixture

of a glucosidal nature, containing nitrogenous, carbohydratic and fatty radicles. Protein has been experimentally decomposed into these radicles, outside the body, by the above investigators; and it has been determined by Cohnheim, Seegen, Külz, Mering and others, through artificial conditions of diet, that the same cleavage occurs as a result of the processes of oxidation within the organism. The non-nitrogenous radicles have as their object the production of energy; and when the systemic needs are satisfied as regards nitrogen, it is obvious that, for the tropics, such force-food as may still be required is preferably supplied in the simple proximate forms not requiring such cleavage—with its necessary production of heat—and not yielding, in the process of decomposition, considerable quantities of a substance which is in excess of the immediate requirements of the organism, and, as stated by Foster, can be stored up in but extremely small part in the system, and hence merely requires elimination as an excrementitious body. Particularly is this the case where the need for internal heat is obviously lessened, and where the renal function, from the causes already mentioned, operates at a disadvantage. It is hence extremely important that protein be supplied in the tropics purely for the purpose of systemic repair and not be relied upon for the creation of any considerable proportion of the energy required by the organism. The ingestion of a certain amount of nitrogen is indisputably necessary to health, and with its deficiency the food ceases to be digested and a condition of inanition ensues. This, however, is no argument for its supply in excessive amount; and the nitrogenous intake—for the most satisfactory accomplishment of the metabolic processes—should be directly proportioned to body-waste. According to Gayet, the average man at ordinary labor, in the temperate zone, loses 20 gm. of nitrogen daily, nearly all of which is in the urine. Eijkman, in Java, found that the average excretion of nitrogen in Malays of a similar class was 7.817 gm.; which, being reduced to a common standard of weight at 145 pounds—the Malays averaging 111 pounds—gives 10.21 gm., or about one-half the quantity ordinarily eliminated in temperate regions. The nitrogen in the standard diets for laboring men in cool climates, proposed by Playfair, Moleschott, Atwater and others, varies from 18.35 to 20.29 gm. Notter and Firth give 11.6 gm. as the daily allowance for a mere subsistence diet in temperate regions, and state that even as much as 32 gm. may be required during great exertion. On referring to the table already given showing the dietaries employed by laboring classes in the tropics, reduced to a common standard of weight for purposes of comparison, it is seen that the hard-working native of the low latitudes ingests an average of 12.83 gm. of nitrogen, or an amount only slightly in excess of the theoretical requirements for bare subsistence for men of the same weight in temperate climates. This deficiency in the amount of nitrogen ingested by the native is, however, apparent rather than real; for the above quantity, small though it may seem, has been shown by experience through untold generations to be not only sufficient for the maintenance of life and health in the tropics, but also ample for the greater demands upon the organism resulting from labor. Maurel, in his study of the natives of Guadeloupe and Guiana, found that their diet was almost wholly vegetable. From estimates based on official figures, he showed that the inhabitants of Guadeloupe used a daily average of only 20 gm. of meat per capita, and that only one-seventh

of the vegetable food was imported in the form of the cereals of the temperate zone; the remaining six-sevenths being made up of yams, cassava, sweet potatoes, bananas, mangoes and other fruits. Similar customs as regards food are said by Eijkman to prevail among the Javanese Malays; and in India and Abyssinia, Church and Lapicque found that the natives rarely used animal material in any form. For natives of the tropics, it may therefore be accepted that the vegetable kingdom is almost wholly the source from which their food is drawn, and that but little of the vegetable material so used is imported in the form of cereals grown in cool climates. These facts are extremely important, for fruits and vegetables grown in the tropics, at least as far as the western hemisphere is concerned, are much less rich in nitrogenous constituents than are the vegetable foods indigenous to the temperate zone. A comparison of the vegetable materials most commonly employed as staple foods in the tropics and in cool climates shows the following differences:

VEGETABLE FOODS CHIEFLY USED IN THE TROPICS.

	Water, per cent.	Protein, per cent.	Nitrogen, per cent.	Fat, per cent.	Carbohydrates, per cent.	Crude fiber, per cent.	Ash, per cent.
Cassava	61.30	0.64	0.102	.17	36.50	0.88	0.51
Sweet potato (edible portion)	69	1.8	.288	.70	26.10	1.30	1.10
Yam	71.86	1	.160	.20	25.05	1.03	.86
Sugar-cane	75.41	1.49	.230	..	15.36	7.04	.69
Ripe bananas (edible portion)	75.3	1.3	.208	.6	21	1	.8
Rice	12.3	8	1.280	.3	78.8	.2	.4

Average amount of nitrogen, per cent., .378.

VEGETABLE FOODS CHIEFLY USED IN TEMPERATE CLIMATES.

	Water, per cent.	Protein, per cent.	Nitrogen, per cent.	Fat, per cent.	Carbohydrates, per cent.	Crude fiber, per cent.	Ash, per cent.
White potato (edible portion)	78.3	2.2	0.352	0.1	18.0	0.4	1.0
Wheat flour	12.8	10.8	1.552	1.1	74.6	.2	.5
Oatmeal	7.3	16.1	2.575	7.2	66.6	.9	1.9
Cornmeal, granular	12.5	9.2	1.472	1.9	74.4	1	1
Barley flour	11.9	10.5	1.520	2.2	66.3	6.5	2.6
Rye	12.7	7.1	1.135	.9	78.5	..	.8

Average amount of nitrogen, per cent., 1.434.

In these two groups of food-stuffs, the great inferiority of the vegetable diet of the native in the tropics, as regards available nitrogen, is at once apparent; the vegetable and cereals most commonly used as food in the temperate zone containing, in a given weight, almost exactly four times more nitrogenous material. Hence, it is evident that the native diet in the tropics is doubly inferior as regards nitrogen; meat being but little used, while the vegetable foods which replace the cereals of temperate climates contain but a small proportion of this element.

The fact may here be emphasized that nature has laid down certain laws as regards alimentation which it is the highest wisdom not to disre-

gard. It is not a matter of theory but an unrecognized chemical instinct which leads the native of the tropics to make his choice of diet and nature's provision of aliment accord so closely. The inhabitants of warm climates, civilized and savage, succeeded in properly adjusting their diet through experience alone long before any theories as to the proper diet for such climates were advanced; and it is worthy of note that not only is a light vegetable diet, containing proportionately little nitrogen, sufficient to maintain health and strength in the native of the tropics, but whites even, who may have been born in hot countries, intuitively adopt a similar regimen and thrive upon it. Habit, in the use of certain classes of food-stuffs, certainly operates against a change of diet; yet Eijkman found, in Java, that the food of resident whites—born in Europe—ultimately approached the native dietary, presenting a marked decrease in both protein and fats. Analyses of this modified European diet gave an average content of 99.6 gm. of protein, 83.8 gm. of fats and 284.2 gm. of carbohydrates. The fact that an excess of meat in any form, greasy meat especially, soon becomes distasteful under the ordinary conditions of life in the tropics is certainly a powerful argument for an alteration in diet in favor of a diminution of protein as well as fats.

The most striking effect of a highly nitrogenous diet is the increase in the nitrogenous metabolism of the body, and to a lesser degree of the non-nitrogenous also. This increased metabolism, through the amount of heat necessarily generated in the process, is clearly undesirable in warm climates. Further, the deficient supply of oxygen available in the tropics impairs the combustion of proteids, and under such conditions the over-loaded system habitually contains an undue amount of unoxidized nitrogenous matter, which in an oxidized state would be eliminated by the kidneys. Albuminates, and nitrogenous compounds generally, undergo change and are excreted principally as urea; therefore an excess of albuminous food throws more work on the kidneys, which may induce disease. Nitrogenous matter being in excess and the secretion of the urine by the kidneys being decreased, there may be deposits in the urinary passages in the shape of uric acid, or in other parts as urates, through the lack of sufficient fluid for their solution.

As to the liver, Rochard, Moore, Nielly, Rattray, Jousset, Maurel, Treille and others have observed the directly injurious influence of a too nitrogenous and greasy diet in the production of disorders of this organ. Hepatic disease, while extremely common among the whites of India and other tropical regions, is rare among the native population. The idea has been advanced that the native enjoys an immunity to this affection as a result of acclimation rather than diet; but this theory is contradicted by Maurel, who states that he, with others, has repeatedly seen congestion of the liver occurring in natives of the tropics, who a few months before, by reason of circumstances, had adopted the much more nitrogenous diet of the temperate zone. This view is upheld editorially in a recent issue of the *Journal of Tropical Medicine*, which calls attention to the greatly increased liability to disease of the liver among Asiatics who have become semi-Europeanized, and connects it with the fact that these individuals crave and use the same bulk of the more concentrated and nitrogenous diet of the European as they do of their own native foods. Further, to show

the injurious effect of a nitrogenous diet in hot countries, laboratory experiments are not wanting. Maurel, in Guiana, fed a series of rabbits upon a vegetable diet, while another group was fed entirely on cheese. The investigation extended over a period of ten months and the results were conclusive, showing a less increase in the weight of the first group than occurred in the cheese-fed rabbits. Not only was the total weight of the second series of animals much greater than that of the first, but the disparity in hepatic enlargement was even more marked, the livers of the latter class showing disproportionate increase in size and also exhibiting manifest changes—being hard, mottled and presenting a condition of hypertrophic cirrhosis. In a second series of experiments, the results, though positive, were slightly less marked, since the experimental feeding continued for only six instead of ten months, and the influence of a nitrogenous diet was not so pronounced upon the liver. The following results were obtained by him:

Duration of Experiment, Ten Months, June, 1881, to April, 1882.

	Total Weight.		At End of Experiment.	
	Before experiment, grams.	After experiment, grams.	Weight of liver, grams.	Relation of weight of liver to total weight.
Rabbit No. I. (vegetable diet)	650	1,210	37	1:32.70
Rabbit No. II. (cheese diet).....	580	1,780	86	1:20.69

Second Experiment, Duration Six Months, April, 1882, to October, 1882.

	Total Weight.		At End of Experiment.	
	Before experiment, grams.	After experiment, grams.	Weight of liver, grams.	Relation of weight of liver to total weight.
Rabbit No. I. (vegetable diet).....	629	1,160	33	1:35.15
Rabbit No. II. (vegetable diet).....	645	1,880	44	1:42.72
Rabbit No. III. (cheese diet).....	467	1,365	48	1:28.44
Rabbit No. IV. (cheese diet).....	565	1,370	45	1:30.44

For the three rabbits given a vegetable diet, the ratio of the weight of the liver to the total body-weight was 1:36.85 at the time of death, while the ratio for the cheese-fed rabbits in this respect was 1:26.52. In view of the clinical experience and experimental results, as noted above, no further argument as to the influence of a too nitrogenous diet in the tropics in provoking liver disease is required.

From what has been said, it may be accepted that the full nitrogenous content of the established ration is in excess of the needs of troops performing garrison duty in the tropics, and under such circumstances the use of food-stuffs containing a considerable proportion of nitrogen may be safely and advantageously diminished. This is perhaps best accomplished at the expense of the meat component, which, besides protein, also contains a considerable proportion of fats. A complete fall to the nitrogenous level of the native of the tropics is undesirable, however, and it is probable that the daily allowance of nitrogen cannot be safely reduced below 16 gm.—represented by 100 gm. of protein—even though this amount is in con-

siderable proportionate excess of the nitrogenous intake of the corresponding native class of the tropics.

In hot climates, where the human organism instinctively feels the need of a loss of heat rather than its creation, the consumption of fat—a heating food of the highest degree—should be reduced to the minimum, and largely replaced by that of sugars and starches, except in the case of troops performing hard service, where force-food of high potential value is required. The craving for sweets noted among our troops stationed in the Philippines gives practical evidence on this point. Rubner calculated that 100 parts of fat, burned within the body, yield as much heat as 232 parts of starch or cane-sugar; and the distaste for fats in any considerable quantity, so early acquired in the tropics and so noticeable during the summer weather of temperate climates, may be regarded as evidence of an unconscious but instinctive recognition of the fact that a dietary of decreased caloric value is sufficient for the needs of the organism exposed to high temperatures and performing no severe muscular work; the more concentrated heat-producers being rejected in favor of bulky vegetable foods of lower potential value. This dislike of fat under conditions of high temperature and but moderate exercise is too fully appreciated to require the production of evidence on this point. It is of interest, however, to recall the aversion with which the ration of bacon was regarded by troops in Cuba and Porto Rico during the war with Spain; while Cardwell reported from Manila that "the salt meat (bacon) was in great part wasted and need not have been issued except in sufficient quantity to provide cooking fat." During hard field service, however, fats may be relished in the tropics, since they supply in concentrated form the energy required for the performance of exhausting labor.

As compared with carbohydrates, fats, as a whole, are notably less digestible, and thus increase the evolution of heat through the more active chemical processes in the intestines. Furthermore, they are burned with more difficulty within the organism, since there is sufficient oxygen in the carbohydrate itself to form water with the hydrogen present, while fats require additional oxygen to combine with their hydrogen for their combustion and elimination. Hence, in herbivora, according to Foster, a larger proportion of the oxygen consumed reappears in the form of carbonic acid than is the case with carnivora, subsisting chiefly on proteid and fat. That this difference is by no means small is shown by the fact that the so-called respiratory quotient, obtained by dividing the excretion of carbonic acid by the consumption of oxygen, by volumes, is about .9 in herbivora and about .7 in carnivora; a difference of 22 per cent. In the tropics, however, it has already been shown that there is a greatly diminished value, as regards oxygenation, to the respiratory act; and under such circumstances the amount of oxygen, already small, available for the needs of the organism as regards the elimination of carbon, would be seriously encroached upon in the oxidation of a diet largely composed of fatty material. Furthermore, an excess of hydrocarbons in the food calls for increased hepatic action in the production of bile, since it has been abundantly demonstrated that the latter is a prominent factor in the digestion of fats, as shown by the fatty stools which follow obstruction or ligature of the bile-ducts.

That this hyper-stimulation of the liver—with its many evil results, elsewhere discussed—actually does occur in the tropics where more fats

are introduced into the system than can be readily utilized, is shown by the bilious diathesis so common among gross eaters in warm climates, as characterized by excessive bile production and later by hepatic congestion. Fats and carbohydrates are much more akin to each other than is either to proteid; and if, as stated by Foster, fat may be converted into sugar either when about to be incorporated into the organism or when being decomposed into its ultimate products, it might reasonably be expected that carbohydrates and proteid, with little or no fat, would form a satisfactory diet. That this conclusion is, in practice, largely borne out by facts is shown by reference to the foregoing tables in connection with the composition of vegetable food-stuffs, in which the fatty constituent of the vegetables ordinarily composing the diet of the native of the West Indies is only .32 per cent. while the corresponding part of the diet in temperate climates contains 2.23 per cent., or an amount seven-fold greater. On this point, however, experience is probably to be trusted. Natives of hot countries, when they can afford it, generally use a small amount of fats as such—as the clarified butter of India, the salt pork of tropical America, the olive oil of the Mediterranean districts and the palm oil of equatorial Africa—but where such a great deficiency exists in the natural fats of the vegetable portion of the diet, even the use of an apparently considerable amount of bacon or other greasy food would fail to make good the deficiency in fats as compared with the dietaries of temperate regions, depending upon the above cause. It is probable, also, that a certain quantity of fatty material, together with the proteid and carbohydrates, assures a better use of the alimentary principles and reduces to a minimum the quantity of each which should be ingested. While it may, then, be conceded that a certain quantity of fatty food is a desirable component of the diet in warm climates, it is certainly true that the amount so taken should be relatively small, and that the proportion commonly maintained in temperate climates is far in excess of the needs of the organism in the tropics. This fact is abundantly demonstrated by referring to the average dietary for men at hard work in the north temperate region and that for the corresponding class in the tropics, as previously given; the fats and carbohydrates being seen to exist in the ratio of 1 : 5.5 in the cold climates, while in the tropical dietary the relative proportion is 1 : 14 for men of the same weight. With such wide variation in the relation of these proximate principles, and in view of the fact that a considerable diminution in protein has also been shown to be desirable, it is evident that a sudden reduction of fat in the ration to the low standard of the native dietary in the tropics might readily provoke such alteration of metabolic function and such interference with existing processes of digestion as would result in serious discomfort and positive detriment to the individual. The dietetic customs of a lifetime cannot be entirely changed in a day, and a stomach accustomed to rich and concentrated food would undoubtedly find difficulty in at once properly digesting a far more bulky and less nutritious diet composed chiefly of vegetable material. For the new-comer in the tropics, habit as well as climate must be given consideration in the selection of diet; and it is therefore probable that no smaller proportion than that of one part of fats to ten of carbohydrates would be to the best interests of the United States soldier under the routine duties of garrison life.

Carbohydrates are justly regarded as the chief source of carbon supplied to the organism in the production of energy. This, however, is due rather to the much greater quantity of carbohydrates ingested, as compared with the fat and protein constituents of the ordinary diet, than to a high proportion of this element in the carbohydrate itself, for the amount of carbon in starch and sugar is relatively low. Notter and Firth state that carbohydrate contains only 44 per cent. of carbon, where fat contains 76.5 per cent. and even protein contains 53 per cent. Through the considerable quantity of protein which enters into the diet, it is thus evident that the latter plays no small part in determining the carbon intake, as utilized for the creation of energy. The urea of the urine practically represents the whole of the nitrogen which passes from the body, and in any given quantity of urea the amount of carbon is far less than that found in the quantity of protein containing the same amount of nitrogen. Foster states that the percentage composition of the two is as follows:

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.
Urea.....	25	6.66	26.67	46.67	....
Protein.....	53	7.30	23.04	15.53	1.13

It is thus readily seen that 100 gm. of protein, which have been suggested as furnishing about the amount of nitrogen desirable for the ordinary allowance of the United States soldier in the tropics, contains as much nitrogen as 33.3 gm. of urea; but the 100 gm. of protein contain 46.4 gm. more carbon than do the 100 gm. of urea (53 : 6.66, or about the proportion of 8 : 1). Hence the daily allowance of protein for tropical service, in passing through the body and giving rise to urea, would leave behind 46.4 gm. of carbon to combine with oxygen and undergo elimination as carbon dioxide. It has been shown that the average diet of laboring men at hard muscular work in the cooler portion of the temperate zone contains 152 gm. of protein, and reduction in this respect to 100 gm., the proposed standard for the tropics, implies a loss of 15.08 gm. of carbon previously available for purposes of energy. It is true that a certain amount of protein taken in as food, as shown by Mallet, is not directly decomposed to the comparatively simple forms of urea and carbon dioxide, but, retaining a greater proportion of carbon, is excreted as creatinin or uric acid—bodies which, intermediate between protein and urea, form a series in which the proportion of nitrogen becomes larger and the carbon smaller—and it is probable that the amount of these substances is considerably increased in the tropics through deficiency of oxygen available for the metabolic processes of the organism. In quantity, however, they are undoubtedly at all times so small as to be safely disregarded for the purposes of the present calculation.

As regards fats, as stated above, carbon enters into their composition to the amount of 76.5 per cent., and it has been shown that for the tropics the proportion in the dietary of one part of fats to ten of carbohydrates probably redounds to the best interests of the American soldier. On referring to the table giving the proximate composition of the average diets of hard-working men in the cooler portion of the temperate zone, it is seen that the amount of fats ingested by this class, 119.5 gm., would be re-

duced, according to the above proportion, to 66.6 gm., or, in round numbers, to a daily allowance of about 65 gm. in hot climates. This amounts to a reduction of 54.5 gm. of fats and 41.69 gm. of carbon; making the total loss in carbon, due to diminution in the fat and protein constituents, amount to 56.77 gm. daily. The average working diet for cool climates, just referred to, contains 453.39 gm. of carbon available for the maintenance of body-heat and the performance of external muscular work; this quantity, on subtracting the 56.77 gm. of this element withdrawn from the same diet through proposed reduction in fat and protein, being reduced to 397.62 gm. But it has been shown that the native of the tropics performs hard labor on a diet which, even when proportioned for an average weight of 145 pounds, yields only 319.16 gm. of carbon presumably available for purposes of energy. It is undoubtedly true that this relatively small amount of carbon, required by the natives of the tropics, expresses to a considerable degree the lessened amount of energy necessary in the maintenance of body-heat in hot climates, and hence approximation to the carbonaceous level of the native dietary would seem to be desirable. On this point, however, the question of previous habit must be given consideration, as is also the case with respect to the fatty constituents of the diet, and such great reduction in the carbohydratic element in the food would, in reducing the nutritive value of the diet, unduly decrease its bulk. Further, the work required of the soldier, even under conditions of garrison life, may at times be somewhat greater than that performed by the native laborer in the tropics. It has been stated that a greater part of the carbon oxidized within the organism is derived from carbohydrates, the latter being regarded purely as a force-food and as the chief source of energy within the body. Such material is capable of largely replacing fat in the dietary, diminishes nitrogenous metabolism, yields no end-products to be excreted by the kidneys, is readily assimilated and, when in excess, is largely stored up within the organism as glycogen and adipose tissue. The ingestion of carbohydrates, therefore, in quantities greater than are required for the immediate needs of the economy, while not without certain untoward effects upon the system, is undoubtedly far less inimical to health in the tropics than where there is an excess of protein or fat in the dietary. It is probable, therefore, that further reduction in carbon for the proposed tropical standard of diet need not be great, as far as any seriously unfavorable effect upon the organism is concerned, and it has been advanced by the writer, in his Prize Essay to the Military Service Institution, on the ideal ration for an army in the tropics, that about 380 gm. of carbon available for purposes of energy should be supplied daily, not including the carbon required in the formation of urea—this being yielded by the proximate principles of the subjacent dietary.

From what has been advanced, it is seen that the proportionate composition and fuel value of the proposed tentative dietary standard for United States troops, performing routine duty in the tropics, is as follows:

Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.	Total carbon, grams.	Nutritive ratio protein to energy).
100	65	650	3,481	16	390	1:8

That this nutritive standard is sufficient for such conditions, in each and all respects, is shown by the fact that it closely resembles the dietary found by Atwater to be employed by farmers in the northern part of New York State. Certainly an allowance of food adequate for the performance of hard labor in a more rigorous climate should abundantly suffice under the conditions of temperature and external muscular work for which the above standard is proposed.

The proximate alimentary principles, whose quantities and relative proportions are given in the above nutrient standard for the tropics, can be properly apportioned in the dietary for hot climates only as a result of an accurate knowledge of the percentage composition of such articles of food as may be selected to enter into its composition. The determination of these foodstuffs, for the soldier, is an easy task. The present United States army ration is made up of admirably selected articles in more than sufficient variety for this purpose; and it is therefore not only wholly unnecessary but quite inadvisable to consider, in this connection, any nutritive substances outside those articles legally established as components of the food for the soldier. The proximate composition of these has long since been determined—as given on pages 161 and 162—and hence the matter resolves itself into the simple problem of so proportioning the quantities of the nutrient articles already provided that, when brought together in varying combination, the resulting dietary will in each case approach the theoretical standards to a reasonable degree. It is not, however, intended that the daily intake of the several proximate principles shall exactly correspond with the quantities laid down therein, for this is manifestly impracticable for the military service, and even if its accomplishment were secured it is more than doubtful if there would be any resulting advantage. The economy readily adapts itself, in the matter of food, to present necessity, and slight deficiency in any nutritive principle is readily made good, particularly in the matter of fats and carbohydrates, from the reserve of these materials stored up within the organism—small systemic losses being subsequently

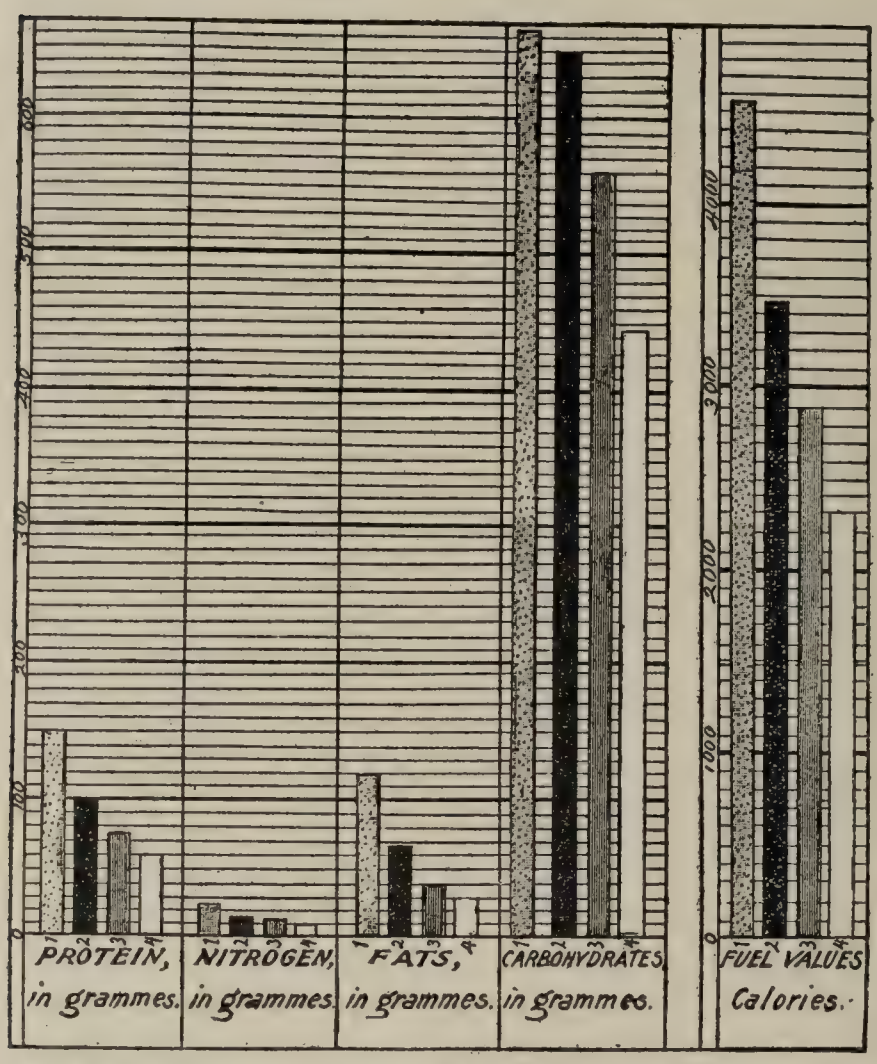


FIG. 371.—1. Standard dietary as given by typical dietaries of men at hard labor in the northern portion of the temperate zone. 2. Proposed dietary for garrison duty in the tropics. 3. Standard dietary for native laborers in the tropics; based on the weight of 145 pounds for purposes of comparison. 4. Standard dietary of the laboring class of natives in the tropics (Java, British India, Guadeloupe, Abyssinia), as determined from the food actually consumed by them at normal body weights.

compensated for by corresponding excess. It is true, also, that the needs of the economy, as shown by appetite, are subject to wide variation; and hence it may be accepted that slight but carefully considered alterations in the constituents of the daily dietary, far from being detrimental, are productive of actual benefit. It is obvious, also, that the amount of work to be performed will not be the same under all circumstances, and hence the question should be considered of utilizing the components of the ration in such quantities as to furnish dietaries properly varying in potential and nitrogenous value. It is believed that this is accomplished in the following modifications of the dietaries already shown to be most commonly used by the United States soldier in temperate climates; the subjoined table showing the nutrient value of a proposed dietary for the tropics, containing the greatest amount of food material to be used by the soldier except when on field service:

DIETARY I.

Articles.	Quantity, ounces.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
Fresh beef	10.0	41.68	44.75	....	590	6.67
Flour	18	55.08	5.60	380.46	1,850	7.90
Beans	2.4	15.16	1.22	40.18	240	2.42
Potatoes	16	9.50	.45	81.70	380	1.52
Dried fruit	3	1.77	1.53	33.80	220	.27
Sugar	3.5	....	....	94.25	397	....
Total	52.9	123.19	53.55	630.39	3,677	18.78

Total carbon, 395.14 gm.; nitrogen to carbon, 1:19.6.

The following table shows a proposed dietary in which the fatty constituents attain their maximum and the potential energy is high:

DIETARY II.

Articles.	Quantity, ounces.	Protein, grams.	Fats. grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
Bacon	6.0	15.64	105.06	....	1,042	2.49
Hard bread	18	73.12	6.63	371.81	1,926	11.74
Beans	2.4	15.16	1.22	40.18	240	2.42
Dried fruit	2	1.77	1.53	50.70	220	.27
Sugar	3.5	....	....	94.25	397	....
Total	31.9	105.69	114.44	556.94	3,825	16.92

Total carbon, 328.76 gm.; nitrogen to carbon, 1:23.

The nutrient value of the ordinary dietary is as follows:

DIETARY III.

Articles.	Quantity, ounces.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
Fresh beef	10.0	41.68	44.75	....	590	6.67
Soft bread	20	53.83	6.80	299.20	1,506	8.61
Potatoes and onions	16	8.60	.72	73.09	340	1.40
Dried fruit	3	1.77	1.53	50.70	220	.27
Sugar	3.5	....	....	94.25	397	....
Total	52.5	105.88	53.80	517.24	3,053	16.95

Total carbon, 328.76 gm.; nitrogen to carbon, 1:18.

For the following combination, the several articles of the ration most closely approaching in character to the food materials used by natives of the tropics—proportioned in quantity according to the standard proposed for hot climates—have been selected:

DIETARY IV.

Articles.	Quantity, ounces.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
Fresh fish (cod) whole	14.0	31.73	0.79	....	120	5.07
Soft bread	20	53.83	6.80	299.20	1,506	8.61
Rice	4	8.75	.45	88.87	407	1.40
Potatoes and tomatoes	16	8.17	.54	65.80	297	1.36
Dried fruit	3	1.77	1.53	50.70	220	.27
Sugar	3.5	....	....	94.25	341	....
Total	64.5	104.25	10.11	598.82	2,947	16.71

Total carbon, 327.50 gm.; nitrogen to carbon, 1:19.6.

On averaging these four dietaries, the mean nutrient composition is seen to be as follows:

Dietary.	Quantity in ounces.	Protein, grams.	Fats, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
No. I	52.9	123.19	53.55	630.39	3,677	18.78
No. II	31.9	105.69	114.44	556.94	3,825	16.92
No. III	52.5	105.88	53.80	517.24	3,033	16.95
No. IV	64.5	104.25	10.11	598.82	2,947	16.71
Average	50.4	109.06	37.97	560.85	3,375	17.34

Total carbon, 350 gm.; nitrogen to carbon, 1:20.

It will be observed that while the above dietaries differ considerably among themselves, yet when averaged together in equal proportions they do not greatly vary from the nutritive standard for the tropics already proposed —and this is an additional reason why a selection of the same articles of the ration should not be made from day to day. It is seen that the above average dietary, as compared with the proposed nutrient standard, is still slightly deficient in fats and fuel value and a trifle in excess as regards protein. These defects, if they may be considered such, are, however, readily corrected by a rotation of dietaries, in which Dietary II. is used twice where Dietaries I., III. and IV. are each employed but once. The results of this change are as follows:

Dietary.	Quantity in ounces.	Protein, grams.	Fats, grams.	Carbohydrates. grams.	Fuel value, Calories.	Nitrogen, grams.
No. I	52.9	123.19	53.55	630.39	3,677	18.78
No. II	31.9	105.69	114.44	556.94	3,825	16.92
No. II.	31.9	105.69	114.44	556.94	3,825	16.92
No. III	52.5	105.88	53.80	517.24	3,053	16.95
No. IV	64.5	104.25	10.11	598.92	2,947	16.71
Average	46.7	108.38	69.43	572.06	3,465	17.26

Total carbon, 363.33 gm.; nitrogen to carbon, 1:21.

For the production of a daily dietary closely approximating the nutrient standard already proposed, the use of the articles of the ration in the following quantities is suggested:

Articles.	Quantity per ration, ounces.	Protein, grams.	Fat, grams.	Carbohydrates, grams.	Fuel value, Calories.	Nitrogen, grams.
Fresh beef (quarters)	10.0	41.68	44.75	..	590	6.67
Or fresh mutton	10	46.20	62.90	..	720	7.35
" pork	6	27.54	112.54	..	1,093	4.40
" bacon	6	15.64	105.06	..	1,042	2.49
" salt beef	10	40.27	64.68	..	688	6.44
" dried fish (cod)	10	45.37	1.13	..	197	7.26
" fresh fish, average (whole)	14	31.73	.79	..	120	5.07
Flour	18	55.08	5.60	380.46	1,850	7.90
Or soft bread	20	53.83	6.80	299.20	1,506	8.61
" hard bread	18	73.12	6.63	371.81	1,926	11.74
" cornmeal	20	50.40	12.40	425.80	1,986	7.99
Beans	2.4	15.16	1.22	40.18	240	2.42
Or peas	2.4	16.38	.75	41.80	246	2.62
" rice	4	8.75	.45	88.67	407	1.40
" hominy	4	9.20	.67	88.75	430	1.47
Potatoes	16	9.50	.45	81.70	380	1.52
Or potatoes 80 per cent., and onions 20 per cent	16	8.60	.72	73.09	340	1.40
" potatoes 70 per cent., and canned tomatoes 30 per cent	16	8.16	.58	62.59	297	1.30
Dried fruit (average)	3	1.77	1.53	33.80	220	.27
Sugar	3.5	..	..	94.25	397	..
Or molasses	1 gill.	..	..	56.05	269	..
" cane syrup	1 gill.	..	..	56.25	269	..

It should be understood, however, that these quantities need not necessarily be adhered to, but that they may be varied according to necessity or taste so long as the nutritive standard is approximated. It is not a question of the special articles of food employed nor of the amounts in which they may be used, but is rather one of the total quantities of protein, fats and carbohydrates yielded by the entire amount of food eaten during the twenty-four hours. By referring to the analyses of the articles of the ration given on pages 161 and 162, the nutrient value of any combination, in variety and quantity, can readily be calculated.

Drink.—Coffee, if not too strong, may be taken freely in the tropics; tea should be used sparingly, as when improperly made it has a directly retarding effect upon the digestive function. In a few instances in the Philippines, weak tea and coffee, cooled in porous jars, have been kept constantly on draught in lieu of drinking-water. Acid drinks are much craved, but their use should not be too long continued as inducing dyspepsia and intestinal disturbances; and the same may be said of the milk of the green cocoanut.

The presence of an abundant supply of pure water is an essential in the tropics, and it is not a refinement of caution to insist that, under all circumstances, water supplied for drinking should be sterilized by one of the methods already described. Recently, in one military department in the Philippines, the use of unboiled drinking-water was forbidden and the employment of water of this character regarded as disobedience of orders

and treated accordingly. To assist in carrying this order into effect, a system of daily inspection of drinking-water and canteens was established. Precautions of this character, for ensuring good quality, cannot be regarded as excessive in a matter of such importance. If water be drunk rapidly and in large quantities, it passes into the intestine without being properly subjected to the germicidal action of the gastric juices, and hence permits the introduction of pathogenic micro-organisms, in viable condition, into the more favorable habitat of the bowel. Further, it dilutes the intestinal juices and impairs their activity. The temptation in the tropics is to drink too much and too often. This relieves thirst but temporarily, increases perspiration, adds to the discomfort and is prone to induce gastro-intestinal disorders; hence, it is well to form the habit of rarely drinking between meals—this being readily acquired by force of will. It is important to remember that it is not so much the rapid introduction of fluid into the stomach which allays thirst as its gradual passage over the back of the mouth and fauces.

For drinking purposes, too warm water is nauseating and has no direct influence upon the reduction of body-heat. Hence it is important to cool the drinking-water, and this may readily be accomplished by placing it, preferably after sterilization, in porous earthenware jars, canvas buckets or suitable receptacles wrapped in linen, felt or other suitable material which has been wet, and swinging the same in a current of air, preferably in a window or under a tree, the contents being cooled by surface evaporation. Where ice is available, it may be more conveniently used to lower the temperature of the drinking-water, but a pleasant degree of coolness can always be readily obtained by the method just given. Iced water, when used in excess, has a tendency to benumb the mucous coat of the digestive tract and largely diminish its powers of absorption for the time being; but cold water is never dangerous if drunk slowly or taken in small quantities, even if the individual be greatly over-heated. Its ill-effects lie wholly in its abuse.

Artificial Refrigeration.—The lack of ice and of cold-storage facilities is a want most keenly felt by all natives of cold countries transported to the tropics, and their presence conduces much to the health and comfort of this class. Particularly is this the case with regard to the sick, in the proper treatment of whose diseases, notably sunstroke and typhoid fever, the use of ice is often essential. Formerly difficult to obtain, the natural product was carried in vessels from colder climates; but now ice may be artificially manufactured at any point in the tropics, and at slight cost, by the simple application of a few elementary physical laws. At present there are a large number of forms of apparatus for the production of artificial refrigeration, but the operation of all are dependent upon the fact that heat is necessary for the expansion of gases, and that this heat is abstracted from bodies with which the gas, at the time of expansion, is in close relation.

The principle of the De La Vergne refrigerating system is extremely simple, and may be looked upon as a type of the ordinary apparatus in common use. Ammonia-gas and oil are received into a compressor from which they are discharged together into the oil cooler. The cooled oil drops into the first tank while the gas continues into the condenser, where it is liquefied and collects in the second tank. The liquid ammonia is taken off from a point near the top of the second tank. A little oil is taken over from the

condenser and is conveyed by a pipe, as shown in the accompanying diagram, to a point near the bottom of the second tank, where it remains; since it is heavier than liquid ammonia and cannot rise to get into the liquid pipe of the ammonia supply. The liquid ammonia is then passed through the expansion-cock into the expansion-coil, where it volatilizes into ammonia vapor, which is drawn off into the compressor to pass around again in the order described.

The Condict system, in utilizing the heat-absorbing qualities of ammonia, takes advantage of the strong affinity which this gas has for water —the latter being employed merely as a carrier. Advantage is also taken of the fact that ammonia-gas, having taken up a given quantity of heat, will, on its being absorbed by water, give it out again. The operation of the system depends on the generation of anhydrous ammonia-gas from aqua ammonia in a retort by means of heat direct from steam. The heat is then removed from the gas by condensing or liquefying it in suitable coils of pipe by lowering its temperature by means of running water on the outside of the

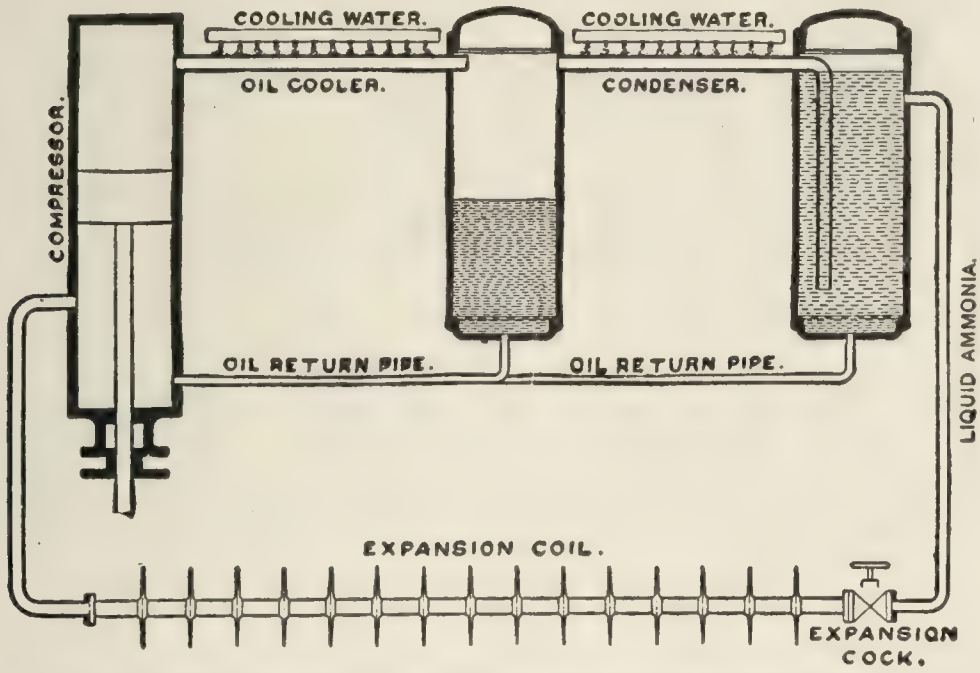


FIG. 372.—Diagram of De La Vergne Refrigerating System.

coils. The liquefied ammonia is then admitted through a small opening in a valve into other coils of pipe. Here, because of the reduced pressure, the ammonia assumes the gaseous state, taking up heat in the process from the surrounding material and producing the desired refrigeration. Having taken up its necessary quantity of heat, the ammonia-gas passes into a suitably designed receptacle known as an absorber and is quickly taken up by the weaker aqua ammonia, delivered through a valve from the retort where the gas has originally been driven off from it. Here also the heat, which the gas has taken up in the expansion-coils, is given out by virtue of the union of the weaker aqua ammonia with the gas; and the heat so given off is carried away by the cooling water which circulates through the tubes of the absorber. Having disposed of its heat, the ammonia is now ready to be returned to the retort and the cycle repeated. This is done by means of an ammonia feed-pump which receives the strong aqua ammonia from the absorber and delivers it to the retort; the aqua or water ammonia thus acting as a carrier of the ammonia-gas.

For the utilization of the cold produced in the two systems above de-

scribed, two methods are in use. In the first, the ammonia expansion-coils are placed in a tank filled with a saturated solution of common salt in water, this not freezing at a temperature as low as that of zero. This brine gives up the heat necessary for the expansion of the ammonia and thus its temperature is continually lowered, the quantity of heat lost naturally depending upon the amount of ammonia admitted to the expansion-coils. To apply practically to refrigerating purposes the cold stored in the brine, the fluid is pumped through coils of pipe placed in the apartment to be refrigerated—the process being analogous to that of heating rooms by steam—and is finally returned to the brine-tank to be again cooled. In the second system, the expansion-coils, instead of being placed in a tank, are run directly into the room to be refrigerated; the ammonia taking up from the air of the apartment the heat necessary to its conversion into the gaseous state.

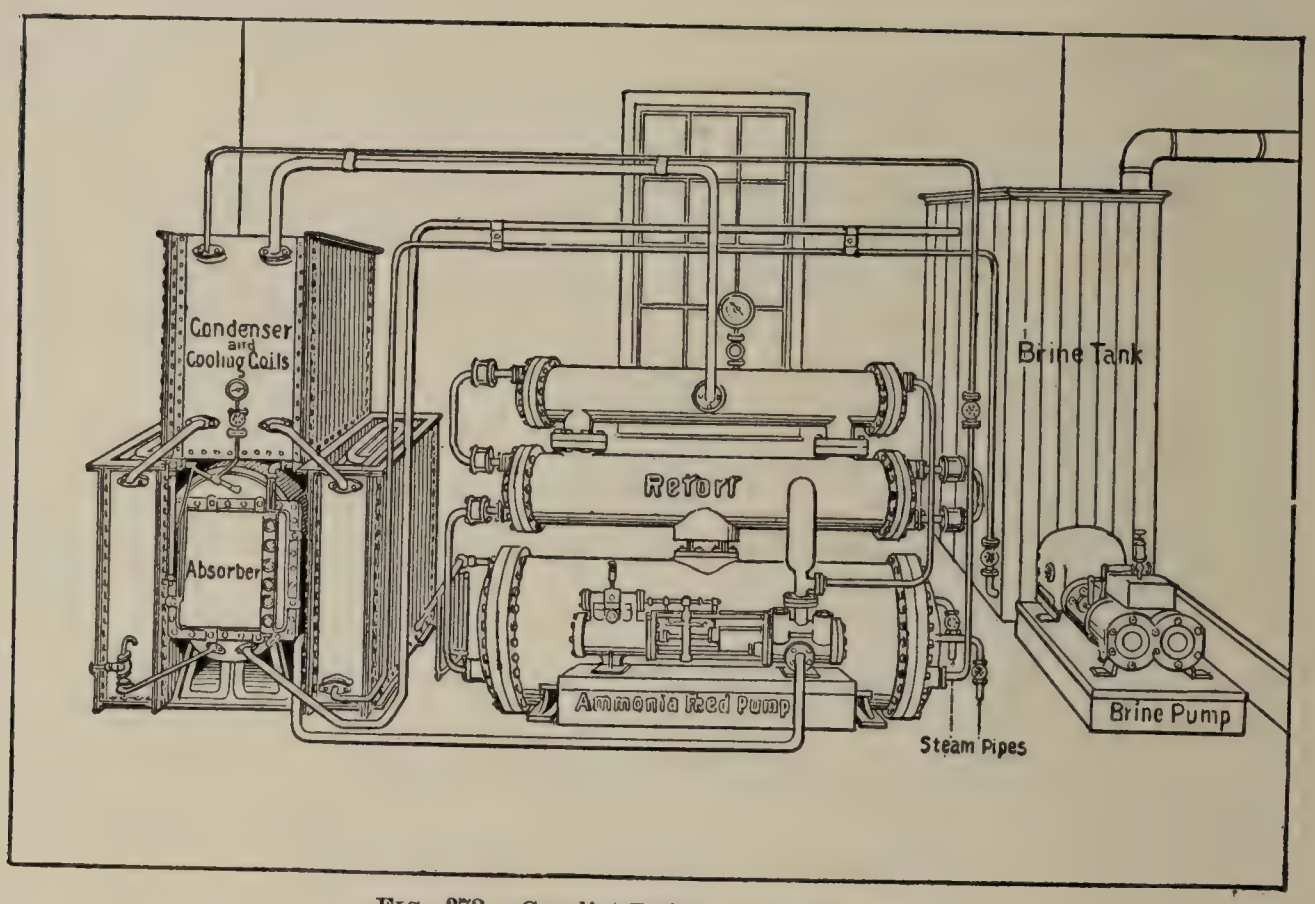


FIG. 373.—Condict Refrigerating System.

The Allen dense-air ice-machine is somewhat different from the foregoing forms of apparatus, in that it uses no ammonia and produces cold by the expansion of ordinary atmospheric air which has been previously compressed and then cooled by circulated water. Starting with air under about sixty pounds pressure, it compresses the same to about two hundred and ten pounds pressure, and in this state it is cooled in a coil immersed in water; and then by an expanding engine the air is brought back to sixty pounds pressure, with resulting low temperature. The cold air is then led through pipes into the brine-tank and, if necessary, may subsequently serve to cool a refrigerating-room, being returned to the suction side of the air-compressor of the apparatus. The machine is particularly applicable to purposes where no great amount of ice-making or refrigeration is necessary, and is much used on board ship. It is extremely simple and compact.

The various forms of refrigerating machines are compared by the effect they produce equivalent to the melting of a corresponding amount of ice. The melting of a pound of ice is equivalent to the absorption of one hun-

dred and forty-two units of heat, the heat-unit being the amount of heat necessary to raise one pound of water 1° F.; but in making ice from water more than one hundred and forty-two heat-units must be removed, since, whatever be its original temperature, the water must be reduced to 32° F. before ice can be produced, and, in addition, ice cannot be made with economy without going to a temperature much lower than the freezing-point. Further, this proportion is still reduced by the inevitable losses attending the use of large freezing-tanks and the handling of the product. Hence the amount of ice actually produced is by no means as great as the theoretical refrigerating capacity of the apparatus, and for all practical purposes is not usually considered to be greater than one-half.

Water is usually converted into ice by mechanical refrigeration through one of two ways—namely, by the so-called "can" and "plate" systems.

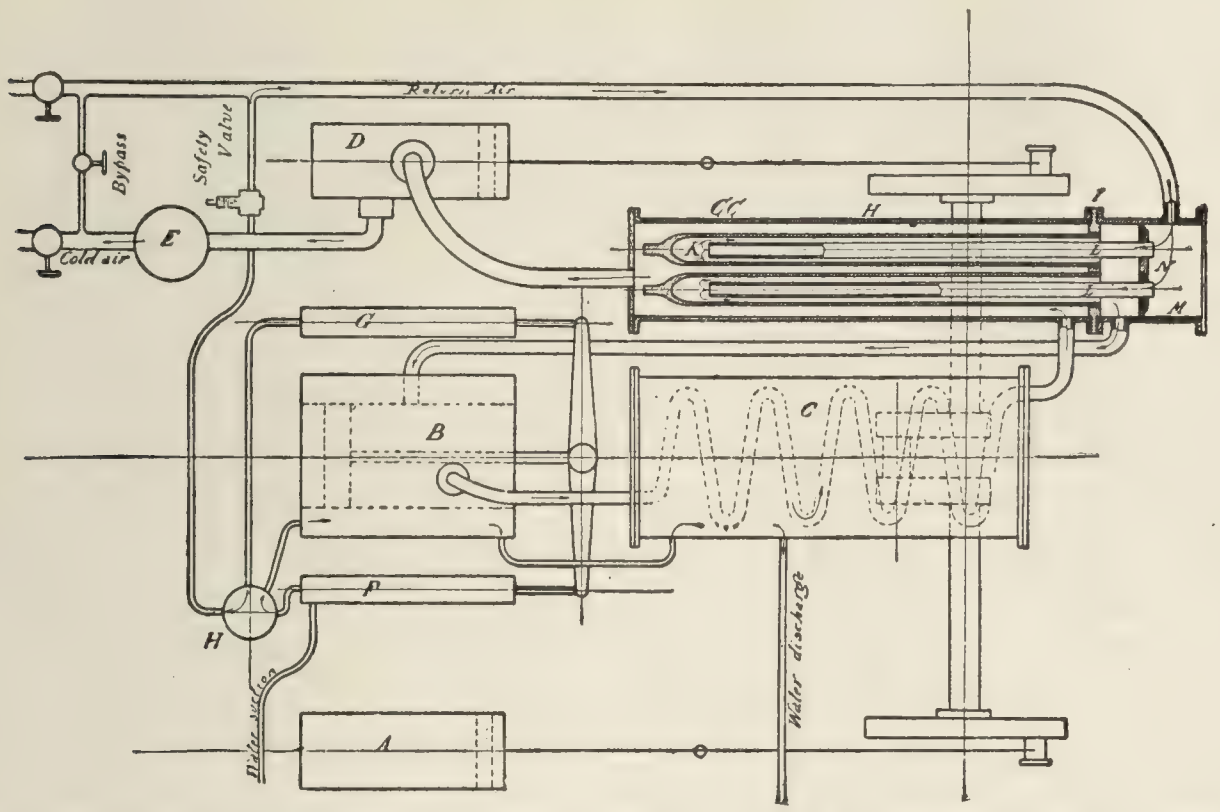


FIG. 374.—Allen Dense-air Ice-machine. *A*, Steam cylinder; *B*, air-compressor cylinder; *C*, water tank and cooling pipe; *D*, expander cylinder; *E*, oil trap.

In the former, the fluid to be frozen is placed in galvanized iron cans, which are immersed in a tank of strong brine. The temperature of the latter is maintained at about 10° F. by the expansion of the liquefied ammonia or compressed air in coils of pipe submerged in the brine which surrounds the can. The low temperature of the brine causes the water to give up its heat; the ice being first formed on the sides and bottom of the can and the center being the last to become solid. The cake of ice thus made is loosened from the can by dipping the latter into tepid water. Because of the continual separation of whatever impurities may be present in the water, and their concentration in the center of the ice-cakes, by the action of freezing, it is essential that all impurities be removed from the water before congelation. This is best done by distillation or long-continued boiling; the process expelling the air and thus rendering the ice not only sterile but also transparent. The latter is a quality which cannot be obtained with the use of ordinary water except by its constant agitation or rapid freezing, and then only in part. In order to economize in fuel, it is desirable to condense the exhaust-steam from the engine into water for the purpose of ice-making,

and for most forms of apparatus this steam has to be freed from the oil used in lubricating the steam-cylinder. This is accomplished by simple steam-filters, and after condensation has occurred the water is again filtered in order entirely to deodorize it. Can-ice thus made contains but a small amount of porous ice in the center—the latter being due to re-absorption of air during freezing—and is not only clearer and purer but also more durable

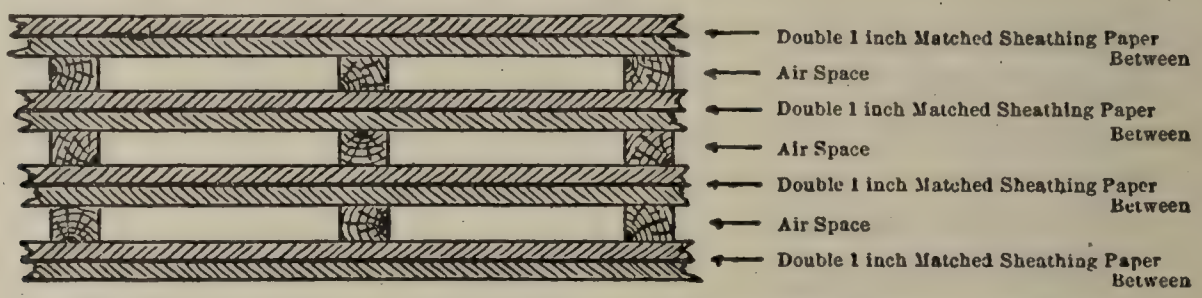


FIG. 375.—Insulation for Main Walls, Wooden Ice-house or Cold-Storage Room.

than ordinary natural ice. The period required for the freezing of a can is usually about sixty hours. In the "plate" system, the ice is frozen direct on plates fastened to expansion-coils submerged in the water. The ice builds up on the plates until it reaches a thickness of about one foot, when it is released by circulating warm gas through the coils and thus melting it off; the plate of ice is then lifted out of the tank and cut into suitable sizes for handling. The mass of ice thus made usually weighs about a ton and requires about ten days for its production. A third method of making ice consists in the use of stationary cells, having hollow walls through which cold brine is pumped. It is evident that in this method, as with the plate system, a whole tank has to be emptied at the same time, and, to make the plant continuous in operation, more than one tank has to be employed. With the can system, on the contrary, there is no loss of time or cold, and the blocks of ice can be taken out of the brine-bath, and cans filled with fresh water set in their places, without interrupting the operation of the whole.

The principles employed in the manufacture of ice are also utilized for the cold-storage and preservation of perishable articles. The chill-rooms, properly insulated, are provided with an overhead arrangement of pipes through which cold brine is pumped or with a coil for the direct expan-

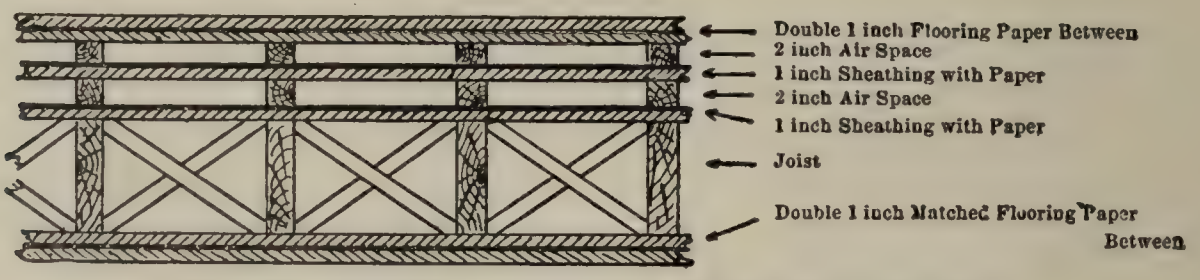


FIG. 376.—Insulation for Ceilings or Floors, Wooden Building.

sion of ammonia or compressed air. This system of mechanical refrigeration is far superior to the use of ice, since not only can a lower temperature be maintained if desired, but atmospheric moisture is promptly condensed on the refrigerating pipes; thus giving not only a cold but dry atmosphere and rendering unnecessary the wasteful and unpleasant practice of trimming refrigerated meats before their use. While exact temperatures cannot be given for the preservation of all foods to the best advantage, it is sufficient to say that beef and other meats, vegetables and fruits are well

kept at about 35° F., and only a few articles, such as butter, cheese and poultry, are best preserved by a temperature below the freezing-point. The maintenance of cold below 25° F. is always undesirable—except in the case of meats which are to be sent long distances in hot weather, and which are preferably frozen solid before shipment.

Few investments in connection with the use of artificial refrigeration are more profitable than money expended on securing good insulation, since otherwise a large proportion of the available energy is lost in overcoming the effects of heat transmitted through the walls of the plant. To prevent this loss, there should be an air-tight surface toward the source of the heat and insulating strata toward the cold side of the wall. It should be remembered that air is one of the best non-conductors of heat, provided it be kept still; but if allowed opportunity to form currents it will convey a large amount of heat from the outer to the inner wall, since rapid movement results when air is free to move between walls differing even a few degrees in temperature. The method of securing insulation is shown in the accompanying diagrams. The filling-in of the interspaces with loose non-conducting material is unnecessary and possesses certain disadvantages. The penetration of air and moisture should be specially guarded against by the use of pitch in connection with buildings of brick or stone; or of paper when wood is used. Whatever the materials chosen for purposes of insulation, they should be free from unpleasant odor and be non-absorbent. In securing insulation in wooden buildings, all joints should be laid in white lead and the insulating paper should be carefully folded and laid so as to overlap. Since the flow of heat is nearly proportional to the difference of temperature between the inside and outside wall, this fact must be given full consideration in arranging insulation, for what is sufficient for a refrigerator or cold-storage room in a fairly cool climate would be totally inadequate in the case of a freezing-room in the tropics.

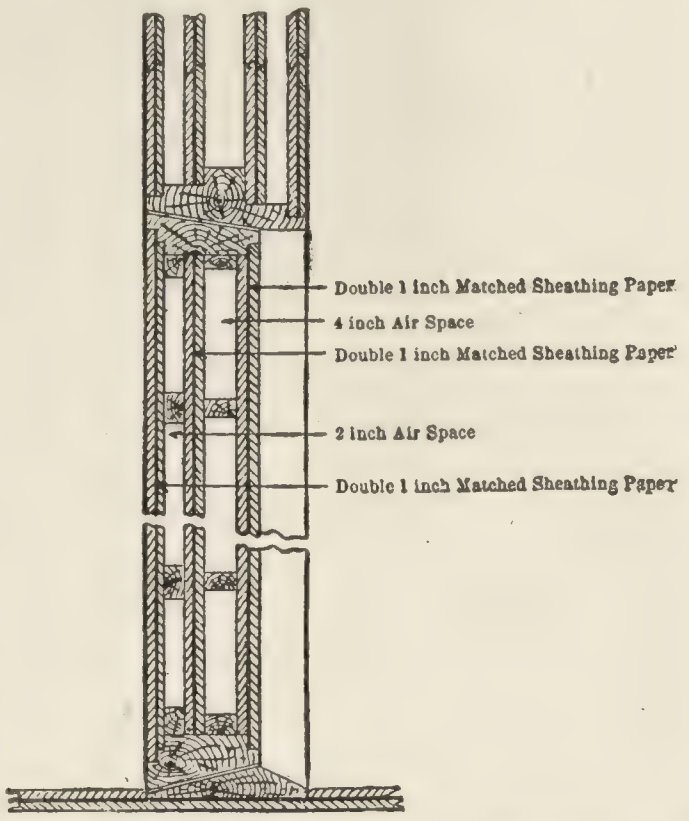


FIG. 377.—Door for Cold-Storage Rooms and Ice-houses.

Clothing.—This, in the tropics, should not only protect from the rays of the sun, as well as from chilling, but should favor the evaporation of sweat and the dissipation of body-heat. It should be light in both weight and color, but should not be too thin, as a certain amount of substance in military clothing is desirable for durability and protection of the person against traumatism. While to have all garments of wool would be unreasonably oppressive, an entire cotton dress would be dangerous for men liable to the sudden exertions of military life, and it is probable that the combination of thin cotton outer-garments with light woolen underclothing is best for the tropics. As the temperature in the tropics undergoes but

slight variation during the year, no change in the weight or texture of the clothing is required for different seasons.

For field service, the color selected for the uniform should be a light dusty-brown, as being best calculated to conceal the discolorations produced by hard service and also being less absorbent of solar heat. Such a color is, however, less inconspicuous than under the ordinary conditions of environment as found in temperate climates, since the prevailing color of vegetation in the tropics, throughout the entire year, is green rather than brown. Theoretically, from the standpoint of conspicuousness on the firing line, the field uniform for the tropics should be of a shade obtained by blending a light green and brown; but the comparatively slight advantage of such a color over the present light brown would seem to be counterbalanced by the undesirability of requiring an already overworked supply department to provide special uniforms for the tropics, the color of which for troops removed to other surroundings, as for this country or during the late expedition in China, would be much less desirable than that now in use. For garrison duty, uniforms of white cotton duck may be issued—a more showy combination for parades being white helmets and trousers and thin blouses of dark blue serge. White, however, has the great disadvantage of soiling readily and presenting a bad appearance without constant washing. This latter defect was avoided to a considerable extent in the uniform of white striped with light blue, used by the Spanish troops on tropical service.

In cut, clothing should be very loose to permit of the ready renewal of the layer of air in contact with the body and the lowering of temperature through facilitating evaporation of perspiration. There should be perfect freedom of action in respect to the body and limbs. The collar of the blouse should turn down; the handkerchief, if necessary, being tied around the neck for its protection. All folds and reduplications of cloth, except a central pleat down the back of the blouse, should be avoided. The latter may serve a useful purpose in giving additional protection to the spine against the solar rays and thus assist in guarding against sunstroke. In cut, the present khaki uniform is admirable; but the blouse may be improved by working ventilating holes in the arm-pits to allow the more free entrance of air. The khaki cloth at present used in the field uniform is cheap, and obviously possesses many excellent qualities for the purpose for which it is employed. Though much lighter than the blue uniform cloth, it is, however, somewhat too heavy and dense for comfort, and is so tightly woven as to interfere seriously with the passage of air—more so than would be the case with light serge. These very qualities of heaviness, smoothness of surface and close texture, however, confer a durability which is of the greatest value during hard field service. For securing this durability, it is important that the cloth employed should be of the best grade attainable; since transportation is a most serious problem in the field, and with widely scattered forces the distribution of new clothing is often slow and difficult. A better quality of clothing means that the soldier can march with a lighter supply, and that the latter need not be renewed as frequently. No economical advantage ultimately results from the issue of articles of inferior quality, and such action may also be productive of hardship to the soldier through the wearing out of his garments under hard service at a time when their replacement is a matter of the most difficulty. Khaki uniforms should

be issued in a standard grade, since, after washing, shrinkage at present not only occurs but the material made by different manufacturers assumes a variety of colors, from almost white to brown. The torrential rains of the wet season render the use of water-repellent clothing essential, and for this purpose all outer clothing issued to the soldier should have been water-proofed with lanolin or acetate of aluminum by the methods referred to elsewhere.

The flannel shirt is an ideal garment for military use in any climate. For tropical service it is superior to the chambray shirt, now issued, but should be made of light-weight material and should be dyed a brown color to correspond with the khaki uniform. The general tendency among troops at present is to wear the blue flannel shirt and khaki trousers in place of the chambray shirt and khaki blouse and trousers. The undershirt is rarely worn with this garment during the day, but is sometimes donned at night to protect the skin from the irritating contact of the flannel. The use of the flannel shirt at night gives excellent results in preventing chilling of the abdomen. It is of interest to note that the Italian soldiers at Massowah, in 1885, simply bound a strip of cloth around the body in lieu of a shirt.

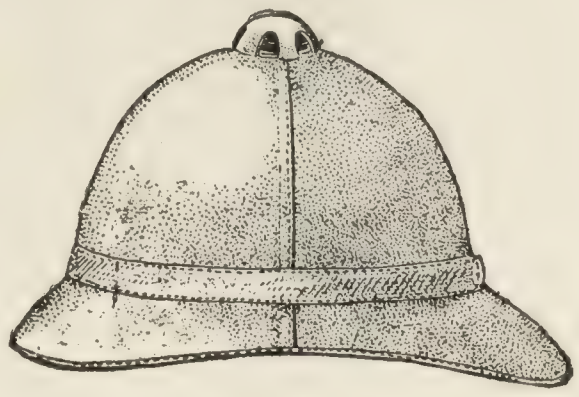


FIG. 378.—Summer Helmet.

All elastic substances soon lose their elasticity in hot climates; and elastic braces in particular, being continually saturated with perspiration, rapidly become stretched and unserviceable. For tropical service, suspenders are thus advantageously made of cotton webbing. It is particularly necessary in the tropics that the use of all confining waist-belts and cross-straps should be avoided.

While the head-gear is of great importance in all climates, it is of the first interest in the tropics; since the head is the part which is at the same time the most sensitive and most exposed to the rays of the sun, and with its proper protection sunstroke is largely avoided. The head-gear should be large, light in weight and color, and should permit free circulation of air and afford protection against sun and rain. It should not only shade the eyes but should also protect the back of the neck. In the French and English colonial services, the cork helmet, covered with light gray or brown cloth and with visors lined with green, is worn during campaign. In our own service, the white helmet is used only for parade or garrison duty; but a special khaki-covered helmet has been issued to certain volunteer regiments in the Philippines. The white helmet is composed of two thicknesses of cork, laminated and cemented together with shellac. The sweat-leather is on a frame hoop, well separated from the shell, for purposes of ventilation, by small corks securely fastened in place. Ventilation at the top is assured by an adjustable ventilator. The helmet is covered with cotton drilling and weighs 6.8 ounces when finished. In the French and English colonial services, the so-called puggarees are worn, but these are inconvenient on horseback, particularly when riding fast. During the British campaign in the Soudan, cork helmets were used and each man was supplied with a veil. Pith helmets are useless in a wet climate. Like

the light white helmet issued in our service for garrison use, they soon become sodden with rain, lose their shape and fall to pieces. Straw hats, as worn by the Spanish troops, are an excellent protection against the heat and are light and inexpensive. They are, however, readily crushed and broken and soon become worthless in wet weather. For service where a change of hats cannot be made, the campaign hat is the only head-gear which has fully answered all purposes. When provided with a separated sweat-band and with large ventilators of wire-gauze in the sides, if thoroughly waterproofed with lanolin and worn with a pointed peak, it affords sufficient protection against the sun, perfectly protects against the rain and is much more comfortable and useful at night than is the helmet. Without waterproofing, this hat soon breaks down and becomes unfit for use during the rainy season. During the very hot hours of the day, the wearing of a wet handkerchief, leaves or grass inside the crown of the hat may sometimes be of service in adding to the protection against the solar rays.

Next to the head it is the abdomen which, in the tropics, especially requires protection. This, in our service, is well afforded by the flannel shirt and drawers worn by the soldier, and hence recourse to the abdominal bandage, held in such high esteem in the British and French colonial services, is unnecessary. However desirable such an additional protection may be in time of cholera or diarrhœal epidemic, the value of its general use in the tropics may seriously be questioned. To march on a hot day with such a band over the abdomen is evidently illogical, since it increases the temperature and weakens the powers of resistance, thus perhaps even predisposing to the diarrhœa which it was intended to prevent. The native West Indian troops of the British army wear a species of zouave uniform, the trousers of which are cut unusually high in the waist and so afford an excellent protection to the abdomen.

In India, putties form part of the military uniform. They are worn over the trousers and give support and protection to the legs, but appear to possess no advantages over the regulation canvas legging of our service, besides being more difficult of adjustment. Cotton stockings are probably best for wear in the tropics, though some prefer those of light wool for marching. The present style of russet shoe, on the whole, appears to give satisfaction for tropical use; but it is questionable if a well-made canvas shoe, with heavy leather toe-cap, would not be preferable. It is of particular importance that shoes should be well-fitting, since abrasions of the cuticle of the feet are a special source of danger in the tropics through the constant opportunity for their infection by the agents producing tropical ulcerations. Rubber-boots should be supplied to guards during the rainy season.

Shelter.—The same general principles for the selection of the site for camp or barracks in temperate regions, already given, apply with even greater force in tropical climates—inasmuch as the question of malaria enters so largely into all considerations—and it is of the greatest importance that military preferences should not be permitted to outweigh evident sanitary defects of site. In general, garrisons should be established on high ground, where the temperature is lower, the air fresher and the soil dryer and more healthful. On the plains, malarial fevers are prevalent, humidity —the great enemy of the white race—is greater and the chemical changes

in a damp and overheated ground go on more rapidly. The difference in temperature between day and night is always less on the plains than on higher ground. From military necessity, however, it is not always possible to select an elevated site, and under such conditions a comparatively unhealthy station must usually be expected. Still, much in the way of improvement may be accomplished, particularly in the special relation of the site to malarial marshes, its thorough drainage and the removal of too dense or rank vegetation. Herbage, kept closely trimmed, should be cultivated in the vicinity of barracks in the tropics to lessen the glare and the reflection of heat. The site should be selected so as to receive the full effect of the sea-breezes or prevailing winds; the immediate vicinity of large cities being avoided. An obviously unhealthy station should unhesitatingly be abandoned, after intelligent efforts at its improvement have been made, as being more economical of both money and lives.

The orientation of barracks in the tropics should be such as to present the least surface to the more direct solar rays, and hence the long axis of the building should be east and west; this rule, however, may often be changed in order to take advantage of prevailing winds. All buildings should be widely separated and should be erected *en echelon*, for better exposure to air-currents. In the British service, the minimum distance between barrack buildings is fixed at sixty feet. The general plan of the British barracks in the tropics is a pavilion having an entrance at the middle with a squad-room on each side, the latter separated from the central hall by two rooms for non-commissioned officers. The lavatories and urinals are at each end, separated by short corridors from the main building. The Spanish barracks in warm climates, and until recently those of the French service, are built in the form of a hollow square. This plan, as already stated, is highly inadvisable under any circumstances, and is particularly so for the tropics, since it interferes with the free passage of air through the barracks and the resulting coolness.

The construction of barracks for the tropics is a matter of the greatest importance; many points having a practical bearing on this subject having been already discussed in connection with the construction of barracks for temperate climates.

The material to be used for this purpose naturally varies with the anticipated length of occupancy of the barracks. It should, in general, be of such a character as to prevent the transmission of heat and the absorption of atmospheric moisture. For temporary habitations, wood is probably the best material, being easily worked and readily obtained and transported; but for permanent barracks in the tropics it should not be employed, since it deteriorates rapidly under the effects of heat, moisture and the attacks of insects. This material requires frequent attention and repairs; and thus wooden buildings, originally inexpensive, are ultimately costly. In addition, they soon become infested with ants, scorpions, rats and other vermin. Hard stone is the best material for permanent barracks; but porous stone should not be employed because of resulting dampness of the walls. In default of hard stone, kiln-dried bricks, painted on the outside, will serve—hollow bricks being better as providing non-conducting air spaces in the walls. The roof should be of tiles rather than of wood or metal. Wood absorbs moisture and furnishes a convenient retreat for vermin, having also the ad-

ditional disadvantage of inflammability and the necessity of frequent renewal. Metallic roofing is a good conductor of heat, and buildings so covered are unduly hot. Tiles possess none of the disadvantages above mentioned and, through the manner in which they are disposed, offer numerous opportunities for the escape of heated air from the building. In the tropics, the use of double roofs, the intervening space being well ventilated, conduces much to coolness—and steeply sloping roofs rather than those which are nearly flat are preferable.

Barracks should be of two stories and the upper floor alone used for living and sleeping rooms, the lower floor being devoted to storage and office purposes. If the building be a frame structure, it should be raised from the ground on piers to a height of four or five feet, and the area underneath the building and for a distance of several feet around its sides cemented or concreted. This concreted space, to prevent small animals and reptiles from taking up their abode under the building, should be closed in with strong wire-net of narrow mesh, should be frequently policed and should never be used for purposes of storage. Where the barracks are of masonry, the lower floor should be eight or ten feet above the ground and the subjacent space thoroughly cemented and ventilated. It is of course particularly necessary that proper means for the conduction of storm-water away from the foundations of the building be provided. Whatever be the material employed in construction, the walls should be double with a free air-space about eight inches in width between the two, and this air-space should have its own special ventilating apertures, properly protected, opening into the external air above and below. For masonry buildings, thickness of walls adds greatly to coolness. Lathing should be avoided; plaster, where used, may be safely applied directly to the inner aspect of the double wall and thus afford less opportunity for the harboring of vermin. The walls and ceilings should be painted, a little coloring being added to prevent glare; their corners should be rounded to facilitate cleansing, and the floors, if of wood, rendered impermeable. Floors of cement, vitrified brick or tiles are cool and desirable for hot climates. They are readily kept clean or disinfected and do not absorb organic matter or harbor vermin. The outside color of the barrack should be cream, light yellow or pale blue to favor reflection of solar heat.

Verandas and galleries, at least ten feet wide, should run the full length of each side of the building. These should have double roofs, properly ventilated, and be provided with jalousies or Venetian blinds; since where verandas are open to the burning rays of the sun, the men are often unable to make use of them during the day and at night they afford no facilities for checking the direct admission of chilly air. Such screens are better fitted to the verandas than to the windows of the barrack-room, and should have movable blades so that they can be reversed to deflect the cool air upward and prevent any direct draft upon the men while heated by exercise, disrobing or asleep. Doors and windows should be large. British army regulations for India require that there shall be one window for every two beds and five doors to each squad-room containing twenty-five men. Windows should be so placed as to oppose each other, to permit of more direct perflation, should be cut to the floor, and should be carried up nearly or quite to the ceiling to prevent the stagnation of the upper layers of air.

They require no glass sashes, but should be fitted with heavy wooden shutters, sawn transversely in the center, for use in chilly weather. These shutters, however, should be controlled by non-commissioned officers, and their closure, except as regards the lower halves, will not usually be required. Nothing in the shape of window curtains should be allowed. The verandas should be protected against flies and mosquitoes by being tightly enclosed with fine wire-gauze, and self-closing doors of the same material should be provided. All windows and doors not opening into such verandas should be protected in the same way. In the tropics, the native houses have no chimneys, but these are preferably placed in barracks. Fires will not often be required, but are occasionally grateful and an open fireplace does much to assist ventilation. The latter assumes a much greater importance in the tropics than in the temperate zone, since free change of air, besides that necessary for the dilution and removal of respiratory impurity, is of value for the lowering of temperature. In warm countries, however, the usual conditions of ventilation are reversed, since the interior of the house is often cooler than the outside; and, hence, for the proper renewal of the air, the use of the wind, in connection with aspiratory flues, must be largely relied upon. Large outlets, carried well up above the roof and painted black, give good up-currents during the heat of the day. In cross-section, such shafts, irrespective of windows and doors, should present an area of at least one square inch for each twenty cubic feet of space to be ventilated. To ensure free circulation of air, it is important that nothing be hung upon the walls—or, indeed, given space in the squad-room—except the bare equipment of the soldier.

The regulations for the British troops in India provide that no more than fifty men are to be quartered under one roof, nor must the number of men in any one squad-room exceed twenty-four. Only two rows of beds are allowed in dormitories and these must be at least nine inches from the wall. But two beds can be placed in the space between two doors or windows and each bed must have at least 7.5 feet of running wall-space. Each man is allowed 90 square feet of superficies and 1,800 cubic feet of air-space. The height of the rooms is fixed at 20 feet and the width at 24 feet. For hospitals, the superficial allowance per bed is 120 square feet and that for air-space is 2,400 cubic feet. In considering these figures, it should be remembered that over-crowding in the tropics is more immediately marked in its effects than is the case in temperate climates, and the sanitary officer must be constantly alert to prevent troops being too greatly concentrated for convenience of administration. The barrack proper should be an entirely distinct building and used merely for living and sleeping purposes. All latrines, wash-rooms, storehouses, kitchens and mess-rooms should be in small detached buildings placed to the leeward. The kitchens and mess-rooms should be well protected against invasion by flies. In tropical expeditions, from the usually wide-spread prevalence of communicable diseases, it is advisable to look upon native dwellings as dangerous shelters and avoid their occupancy.

The air is both hot and stagnant in many parts of the tropics, and its artificial cooling and circulation is practiced in buildings. To meet these indications, the punkah, tattie and thermantidote are employed. The punkah, much used in the Orient, merely consists of a framework of wood and

canvas having a fringe, this arrangement being swung backward and forward from the ceiling by a rope passing over a pulley and worked by hand. The thermantidote is a machine through which, by the rotation of a wheel and fans, a current of air is forced into a room. It has the great advantage of not only putting air in motion but also cooling it, through evaporation of moisture from thin, wet grass-mats suspended in the short discharge-channel through which it passes. The tattie, a loosely-woven mat of fragrant khus-khus grass, hung in the window, is much used in India in reducing the heat. The rapid evaporation of water sprinkled on such grass mats produces a great fall of temperature in the room; thus Fayrer states that, in Oude, with a hot west wind, the thermometer registered 104° F. in the shade outside the house, 83° F. in the house and 68° F. behind the tattie. Merely by sprinkling water on the floors the temperature of rooms may be considerably lowered. If the air be dry, there is no difficulty in cooling the air by the evaporation of water to the extent desired. The evaporation of a gallon of water absorbs as much heat from the air as would raise 4.5 gallons of water from the freezing to the boiling point. As the specific heat of an equal weight of air is one-fourth that of water, it follows that the evaporation of one gallon of water will reduce 26,000 cubic feet of air from 80° to 60° F. If thoroughly utilized, 1.5 gallons of water would be the per capita allowance for twelve hours, but as theoretical results are rarely to be attained in practice, this quantity will usually have to be doubled. In large cities in the tropics, these primitive methods of securing coolness will usually give way to the use of rotary fans driven by steam or electrical power. At stations not directly connected with an electrical plant, small fans, run by a storage-battery, may be employed in hospitals. In this connection it may be mentioned that barracks, in the tropics, should preferably be lighted by electricity; thus securing an excellent light without the production of any great amount of heat or vitiation of the atmosphere.

It may be laid down as an axiom that, in the tropics, troops should not be encamped under canvas if more substantial shelter is available. While with the improved tentage devised by the writer the question of temperature and ventilation may be regarded as satisfactorily solved, the necessity of living and sleeping close to a moist and fermenting soil, without adequate protection against the attacks of insects, greatly favors the occurrence of typhoid and malarial infection. In the Philippines, it has not rarely happened that where troops were forced to bivouac even for a single night on damp or wet ground an immediate and very perceptible increase of the sick-list has been noted. Hence it is that a poor barrack, if free from the infection of disease, may be regarded as preferable in the tropics to the best of tents.

For service in hot climates, the United States army regulation tentage is seriously defective and is extremely hot and close under the vertical sun and in the humid atmosphere of the low latitudes. This fact was commented upon by the inspector-general in his report upon the condition of troops in the West Indies in 1899, and the following comparison of temperatures was made by him in southern Cuba:

Hospital—Brick building with tile roof	84° F.
Officers' Quarters — Wooden building, tile roof, windows shaded	83

Barrack—Wooden building, thatched roof	85
Barrack—Wooden building, zinc roof	86
Common tent, without floor	94
Hospital tent, with floor	95
Conical-wall tent, with floor	102

These figures showed a difference of eighteen degrees of heat between a brick building and conical-wall tent. On reflection, it appeared to the writer that this excessive heat in the tents, particularly the hospital tent, was due: (1) To the impingement of the direct solar rays upon the single thickness of canvas of the walls and ends. (2) To the insufficient air-space and limited opportunity for the movement of air between the fly and roof of the tent. (3) To the inadequate size and improper location of the openings for ventilation. The writer therefore recommended: (1) That the tent-fly be enlarged two feet in length and four feet in width. (2) That this fly be raised upon a light false ridge placed one foot above the



FIG. 379.—Munson Hospital Tent, Front View.

present ridge, the latter being removed and replaced by a rope. The upper ridge to be four feet longer than the ridge of the tent proper and to project two feet to the front and rear. (3) That the canvas comprising the top of the tent be cut out for a space two feet wide on each side of the ridge and running the entire length of the tent—except for one foot front and rear. (4) That the tent fly be of white canvas better to reflect the heat rays, while the tent itself be made of drab canvas, properly to subdue the light in the interior.

The above changes ensured complete protection of the walls—and nearly so of the ends—from the rays of the sun; a large free space, at least one foot wide, between the tent roof and fly, from which the heat is readily driven by perflation; and finally, complete ridge ventilation of the tent itself, rendering the stagnation of heated or impure air impossible. As at present arranged, this hospital tent has forty-eight square feet of ventilating surface where the regulation tent has less than two-thirds of one square foot; and not only does heated air directly escape through this opening but currents of air passing horizontally over the netting under the fly exert a

direct aspiratory effect on the air within the tent itself. The two-foot overhang of the fly, front and rear, implies the pitching of the hospital ward in tent sections four feet apart; the sheltered intervening spaces allowing free lateral ventilation, the complete isolation of patients, direct entrance and egress of the inmates without the necessity of passing through other tents of the ward, and finally, a covered area for the protection of ward property. The temperature of the improved tent was carefully compared with that in an adjoining hospital tent of the old regulation pattern

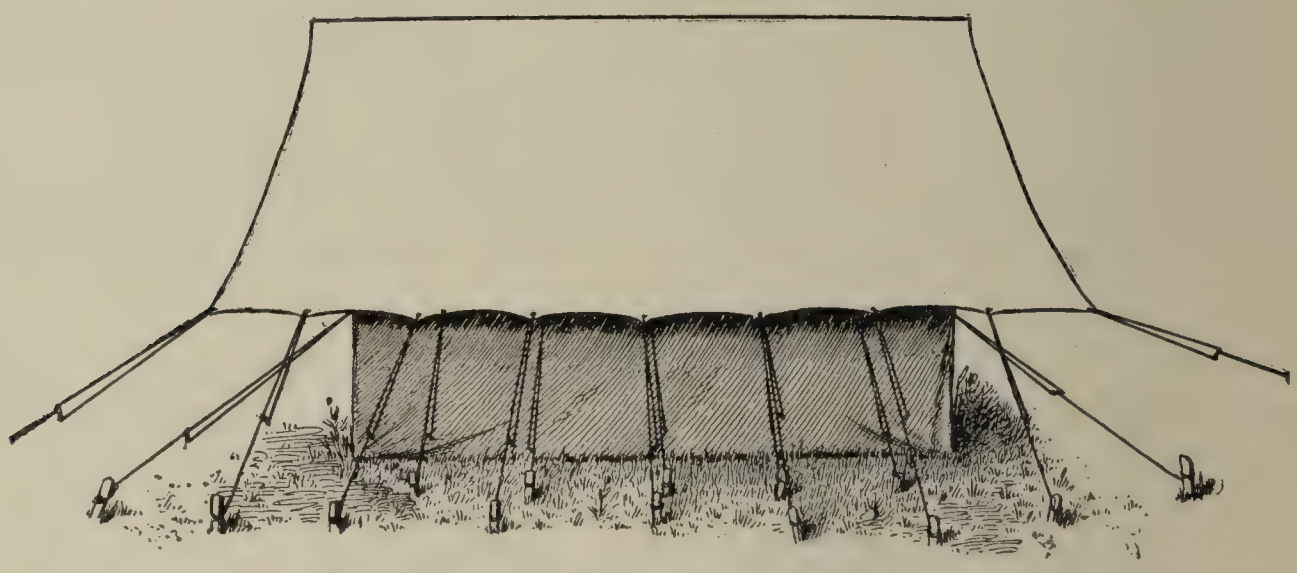


FIG. 380.—Munson Hospital Tent, Side Elevation.

and the new model conical-wall tent, and the temperatures in dense leafy shade and in the sunshine also noted. The thermometric readings were as follows:

Time of day.	In the direct rays of the sun.	In the shade of a leafy tree.	Munson tent.	Regulation hospital tent.	Conical-wall tent.	Remarks.
1...	87.0°	79.5°	84.0°	89.0°	93.5°	Tent walls down.
2....	94	80.5	86	94.5	100	" " "
3....	90	83	86	93	97	" " "
11....	95	84	89.5	99	107	" " "
12....	97	88	93	97.5	106.5	" " "
1....	103.5	88.5	90.5	96	98	Tent walls rolled up.
2....	104.5	93	90	94	93.5	" " "
3....	93	88	89	92	91.5	" " "

These figures show a temperature in the improved hospital tent, with walls down, never more than 5.5° F. higher than in dense shade in the open air and once only 3° F. higher. As compared with the regulation hospital tent, the temperature of the improved tent averaged 87.5° for the latter and 94.5° for the former—an average difference of 7° F. On one occasion, a difference of 10.5° F. was noted. As compared with the conical-wall tent, the temperature ranged from 9.5° to 18.5° lower in the improved tent. It was observed that this tent, with walls down, was only two or three degrees warmer than with walls rolled up—a point of especial value in connection with the treatment of the sick, where the subdued light and comparative quiet and seclusion of the closed tent are desirable. This tent can be made warm and snug for any climate or sudden change of weather by means of a canvas flap, attached to the tent roof by one border, by which

the ventilating opening can be readily closed. This tent has been officially adopted for use in the military service of the United States under the name of the "Munson hospital tent."

The writer also recommended, for tropical use, that the present conical wall tent be provided with a fly, shaped in the form of a truncated cone, having a diameter at its base two feet greater than that of the tent, and supported from a large ring and the center pole, the same as the tent itself. The length of the fly should, of course, be a trifle greater than the canvas of the present tent, exclusive of its wall. This modification has also been shown materially to reduce temperature and promote ventilation. To increase ventilating action further, the opening of the apex of the fly is made the same size as that of the tent; the heated air rising between the tent fly and the tent roof exerting an aspiratory effect on the air within the tent as it passes over the ventilating opening in the latter. The apex opening of the tent is closed during stormy weather by the movable cap as at present used, the latter being manipulated by ropes passing between the tent roof and the fly.

The common wall tent, on account of its small size and lack of fly, is totally unsuited for use in hot climates. Troops who must live under canvas in the low latitudes can be comfortable only when quartered in the improved tents, just described. Where tents of these models are not obtainable, a certain degree of relief from the heat may be obtained by pitching one wall tent inside of another, spreading additional flies and supporting their corners away from the tent roof, or by erecting a frame over the tent and covering it with green branches. Where the old style tents are used during hot weather or in the tropics, they should contain only half the number of men they are officially expected to shelter. With the writer's improved tents, on the contrary, the ventilation is so free that the inmates are practically in the open air, and hence an even greater number than the authorized allowance may be eomfortably accommodated.

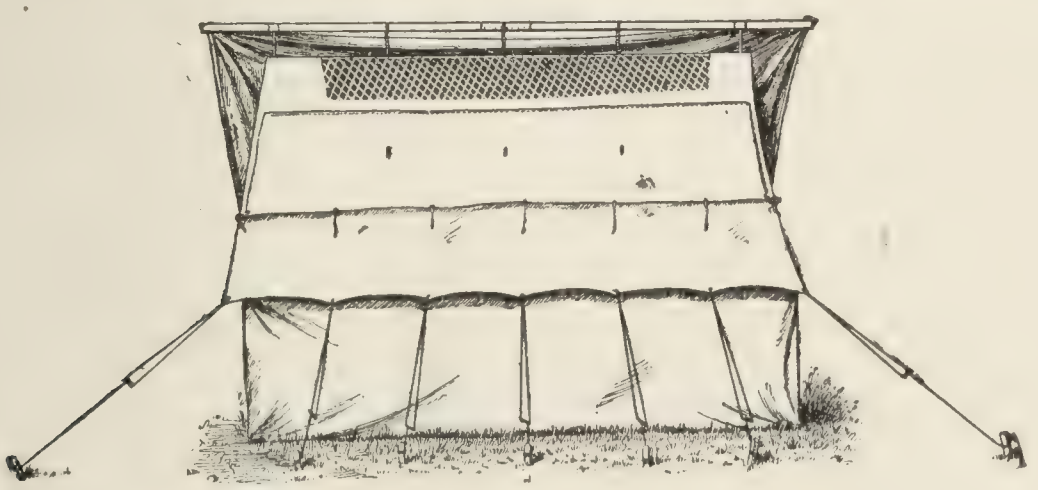


FIG. 381.—Munson Hospital Tent, Side Elevation, Fly Thrown Back.

On marches or campaign, particularly in the rainy season, the shelter-tent will prove the most valuable article of the soldier's equipment. Wherever possible, the men should be instructed to raise rude scaffolds and by pitching the shelter-tents over these to raise their bodies well off the ground. In their effort to reduce weight, however, our troops in the Philippines have not rarely discarded even the shelter-tent halves during active field service. Where shelter-tents are not available, it will be rare that fairly waterproof

"lean-to's" or sheds cannot be quickly constructed from palm branches, grass or bark.

Sleep.—Wherever it can possibly be avoided, soldiers should not be permitted to sleep upon the ground. If this be necessary, the poncho should be used to protect from dampness, but it will usually be possible to raise the body above the ground on extemporized platforms. For tropical use, the regulation woven-wire cot is inferior to one made of bamboo with a closely woven wicker top. The latter possesses sufficient elasticity to be comfortable even without a mattress, allows the passage of air and thus keeps the occupant cooler. For camps, the folding canvas-cots, previously described, are of advantage. If mattresses are used, they should be of shuck or hair and not too thick. Feather pillows should not be employed. As the nights are often chilly, one or two woolen blankets should be available.

The use of the mosquito-bar is essential in the tropics. Apart from the irritability and loss of rest produced by the nightly attacks of these insect pests, their bites are now recognized as being a means for the transmission of malarial infection and yellow fever, and are frequently the starting-points of intractable ulcerations or painful pustules. The net should have a mesh sufficiently fine to keep out gnats as well as mosquitoes—that of the mosquito-bar supplied in our service being much too large for the former purpose.

The use of pajamas as a sleeping-suit is advisable; this practice being cleanly, comfortable in hot weather and especially valuable as not permitting an involuntary exposure of the abdomen or body while asleep. In India, the use at night of a broad woolen sash or cummerbund, wrapped tightly around the outside of the cotton pajamas, is much favored. This special protection is more necessary from the fact that during sleep the physical power of resisting cold is much diminished; and not only is chilling more liable to occur, but its effects are more severe than would result from a similar exposure during the waking hours. For this reason, the practice of sleeping in a draft or the open air, for the sake of greater coolness, is to be deprecated.

In the tropics, the siesta is almost a necessity. The intensity of the sun, in its directness, requires that the middle of the day be spent quietly within doors, and during this period the men should not be allowed to leave the barracks. There is no doubt but that sleep during the day somewhat interferes with digestion and favors wakefulness at night, and hence it would appear logical to avoid sleeping during the day in the absence of unusual fatigue or prolonged lack of repose. On the other hand, it appears to be true that residents in the tropics require more sleep than those who reside in temperate regions, and that, as a rule, nine or ten hours out of the twenty-four should be given to its attainment. Frequently, also, the siesta taken in the middle of the day is more restful than the fitful slumbers of a stifling night; and repose, while itself of advantage, also affords a pleasant way of passing hours in which but little can be accomplished. The actual duration of the siesta should not exceed one to one and one-half hours.

Work and Exercise.—For the white race, the great heat of the tropics precludes the possibility of doing as much work as in a temperate climate; to attempt it is to invite disaster—for the limit of strength and endurance

is soon reached under tropical conditions, and lowered vital resistance through fatigue is especially a potent cause of disease. The production of internal heat by muscular exertion is a matter too frequently overlooked, Foster stating that nine-tenths of the energy required for a muscular contraction is expended in the form of heat and only one-tenth is represented by the work accomplished. Without condemning the troops to absolute idleness, the work to be performed by them should be reduced to the limits of strict necessity, and scavenging and other hard labor, particularly that which must be performed in the heat of the day, should be done by natives. Under no circumstances should work be done in the direct rays of the sun, between 11 A.M. and 3 P.M., and labor implying disturbance of the soil should preferably not be performed by white troops.

It should not be understood, however, that tropical service and physical exercise are incompatible. It is true that the tendency in hot climates is toward a sedentary life and that indolence is a direct result of the relaxed muscular and circulatory systems, but this tendency on the part of soldiers must be combated in the prevention of physical retrogression and mental apathy. Exercise should not, however, be overdone; and the time for its performance should be carefully regulated. The morning, a short time after breakfast, is the best part of the day for its accomplishment. Motion, even the most moderate, is always attended with profuse perspiration; and men who expose themselves to the cool air of night-fall in this condition, with wet shirts upon their backs, are prone to chilling and resulting sickness. After morning exercise, however, the heat of the day follows and prevents any evils of this character. It is true that bad effects might be avoided were the men to put on dry shirts after the evening exercise—but to do this is not always an easy matter for the soldier. Exposure to drafts while perspiring is always to be avoided.

Marching.—This, as far as possible, should not be performed in the rainy season, and should be suspended during periods of the greatest heat. Night marches should be as carefully avoided as those of mid-day. In general, marches should be performed from 5 to 9 A.M. and 4 to 7 P.M.; the men resting during the heat of the day. French colonial regulations allow no marching for infantry between the hours of nine and three—cavalry being allowed to march until ten o'clock. As far as possible, marches should be so timed that the rays of the sun do not fall on the backs of the men, nor should they ordinarily be allowed to exceed ten or twelve miles. In malarious regions, especially, the length of marches should always be reduced to the minimum if the malarious district is too large to be crossed in one or two long marches. Rapidity of marching is undesirable except under stress of military necessity. Since exertion and fatigue are great factors in the production of sunstroke and in the occurrence of disease, it is important that the equipment and burden to be carried by the soldier should be lightened as far as possible. For this purpose, the employment of native porters is usually necessary. The ordinary load for native carriers is from 40 to 80 lbs.; two carriers being estimated to transport as much as one mule. British soldiers, in the tropics, carry only their arms, ammunition and canteens, and the remainder of the equipment is transported by carriers. In the Soudan expedition of the British, the number of porters accompanying the column equalled that of the combat-

ant force; while on the march from Cabul to Candahar, in 1880, with 10,148 troops there were 8,143 native followers and 11,224 transport animals. In the Dahomey expedition of the French, the weight carried by the soldier amounted to about 32 lbs.; the remainder of the equipment, weighing 30 lbs. per man, being transported by carriers. The native soldier of the French colonial army, however, is required to carry his own complete equipment, the weight of which is about 60 lbs. Frequent rests should be given at suitable points during the march, the men being especially cautioned not to lie down on the ground. Asphyxia supervening on extreme fatigue has been frequently noticed in the French army in Algeria, particularly during the occurrence of the sirocco. Even mania has followed protracted marching in the tropics; and in Bugeaud's expedition into Tunis in 1836 there were eleven suicides recorded in the French forces.

Insolation.—No precaution should be neglected in the prevention of sunstroke, which is one of the most serious calamities liable to affect white troops during campaign in the tropics. Thus it is reported by Morehead that in India, in 1858, the Seventy-first regiment lost 89 men by death from insolation between the 5th of May and the 15th of August. The frequency of sunstroke among the British troops in India was very great when the soldier was required to carry the same weight and wear the same uniform as in England, but became much rarer when a special system in this respect was adopted for tropical service. In the expedition of Bugeaud in Algeria, just mentioned, more than 200 men were reported as being sunstruck; but during the campaign of the French army in Mexico insolation was rare, probably through the altitude of the region in which military operations were conducted. The extinction of vitality by extreme heat is also common in temperate climates during the heated period; being perhaps almost as frequent as in the tropics. This is probably due to the fact that, in hot climates, sunstroke is always apprehended and measures are accordingly taken to avoid it by modifications in the way of dress, weight of equipment, hours for marching, rapidity of marching and other conditions. In temperate climates, these precautions are rarely taken in summer and the soldier is thoughtlessly required to manœuver under the heavy garments and burdens of a winter campaign.

Viry states that, on July 8th, 1853, two-thirds of a Belgian regiment were struck down by heat while on the march; and that during the last war in Italy, on a hot July day, no less than 2,000 men in one division of the French army fell out of the ranks from this cause. In 1878, the Austrian troops occupying Bosnia lost many men from sunstroke; one regiment on the march having 320 cases with 31 deaths, while the total number of cases of insolation during the campaign amounted to 2,131. In July, 1879, a regiment of Italian *bersaglieri* left 200 men along the road, overcome by the heat, during a march of 35 kilometers. Sunstroke is said to be particularly common in the German army, and it is stated that on May 21st, 1827, the troops manœuvering near Berlin were completely disorganized by heat, entire companies falling along the route and the cavalry losing many horses. In our own service, but little marching is done, during time of peace, until the heated season is past—but during the ten years 1888–1897 there were 523 cases of sunstroke. In the tropical islands, our troops have suffered considerably from sunstroke during the past two years. During

the recent relief expedition in China the great heat resulted in much suffering; during the march on Pekin there were 8 deaths in a regiment about 1,200 strong, and it is said that at one time about one-fourth of the command was unfitted for marching from this cause.

It appears to be excess of internal heat more than sunshine which results in the phenomena known as insolation; and hence the condition may occur at night if the atmosphere, while hot, is also saturated with moisture, and heat dissipation, through evaporation of perspiration, is imperfectly carried on. Insolation rarely occurs at a high altitude and in a dry climate, no matter how elevated the temperature. Laveran and Regnard have found that as soon as the bodily temperature exceeds 40° C. it begins to exercise a marked influence upon the nervous system; this being greatly increased if the head is exposed to the direct solar rays. Where the condition of insolation is actually established, the heat-regulating centers are disorganized and the temperature is extraordinarily high. Death results from the primary stimulation and subsequent paralysis of the nervous system by the heat. Exercise is a great factor in the production of heat-stroke, and a large proportion of cases among marching troops depend almost as much on exhaustion as upon high temperature. Animals made to undergo violent exertion are more readily made to succumb than those allowed to rest quietly —and in the army it is the infantry which are most affected in this respect, cavalrymen being less liable to sunstroke than are their horses. Exercise greatly increases the production of body-heat, and Hiller found that the rectal temperature in soldiers after a hard march was that of a high fever. The mental strain and unconscious muscular rigidity which accompany military movements undoubtedly favor the occurrence of sunstroke. Anything which interferes with the loss of body-heat increases liability to sunstroke; this including too heavy clothing, diminution of perspiration through deficient water-supply or lowering of the processes of evaporation through excessive humidity. If the atmosphere is both hot and moist, the loss of heat by the lungs is largely impaired; hence in a marching column, carrying with it a close atmosphere saturated with moisture, it is the men in the center of the ranks who are most liable to sunstroke. The period of digestion is favorable to insolation, and it is the debilitated or intemperate who are most liable to suffer in this respect. Insolation is undoubtedly aided by the pressure of tight clothing, or the belts and straps by which the soldier's load is suspended from his person. McCartie, in India, records a striking instance in the Chitral campaign of 1897, when sufficient coolies could not be obtained and part of the baggage had to be carried by native soldiers. Before the end of the march, nearly all the men in the ranks were completely exhausted and some had heat apoplexy, while their comrades, carrying a much heavier weight but having assumed the light and loose native dress, were not in the least distressed.

The races indigenous to hot climates possess a notable immunity as regards sunstroke; this, in the negro, being especially great and furnishing an additional argument for the organization of native forces for tropical service. Some of the symptoms of insolation are said by Notter to be caused by the reflected rays of the sun through the orbit, when the optic nerve is exposed to direct rays of light. In the British service, neutral-tinted glasses are frequently worn as a protection to the eyes, and the

sense of relief experienced by their wearers tells the advantage their use affords. Such glasses in the form of goggles were found effective in the Egyptian campaign of 1882, as a protection against glare, heat and sand. With a better knowledge of the character of light, it has been suggested that the actinic rays may be a strong factor in the production of insolation. These can be arrested by a layer of color used as a filter. Dark red, yellow or green is such a color, and the material or thickness in which it is present is a matter of comparatively little importance. A lining of such a color has been recommended for the head-covering and for the blouse directly over the spine. Recently, in view of the qualities and destructive effects of the Roentgen rays, it has been proposed, for the interception of the latter, also to line the head-gear with a thin layer of tinfoil.

The advance to the condition of insolation is gradual, and its occurrence can be largely prevented by careful observance of proper administrative detail. The march should be so planned as to avoid exercising during the heat of the day; while the length of the distance ordinarily traversed in temperate climates should be diminished—or else the rapidity of movement lessened. Troops should march with as open ranks as possible, better to allow the access of fresh air to each soldier. Halts should be frequent, and at points which are well shaded, elevated and airy. During such halts the men should not lie down, since in very hot weather, particularly if the ground be bare, the soil is heated to a higher degree of temperature than is the atmosphere. Soldiers must have plenty of water, and hence canteens should be filled as often as possible en route. The water should be drunk in small quantities but may be taken at frequent intervals. If a sufficiency of water along the route is not assured, arrangements must be made for the carriage of a supply with the column. This matter is given careful consideration in foreign armies, all of whom have some contrivance for getting extra water into the field. Absence of proper provision of this sort has caused much unnecessary suffering in our own army, an instance of which can be found during the late expedition in China. The use of alcohol in any form, previous to beginning or during the progress of the march, should be interdicted. The clothing worn should be adapted to the climate, should be loose and the head and back of the neck must be well protected. The upper buttons of the blouse may be unfastened and the handkerchief worn under the hat to protect the neck. Troops should not march on an empty stomach, but a hearty meal should not be taken immediately before marching.

During the march, company officers should watch their men carefully. If a soldier looks pale, weak and exhausted, he should be spoken to sharply, and if he does not respond clearly he should be told to fall out and rest or await wagon transportation. Where sunstroke has actually occurred, the man should be carried into the shade, his clothing loosened and his equipment removed. His head, neck and face should be bathed with water and the coolness from its evaporation favored by vigorous fanning. Where the patient is able to swallow he should be given water in small quantities at short intervals, and should be allowed to rest quietly until the arrival of an ambulance and medical attendance.

It should be remembered that many cases of sunstroke result in permanent impairment of the nervous system and in the establishment of

future susceptibility to the action of the solar rays. For the military service, the maxim "once sunstruck, always sunstruck" may be accepted as correct.

Excreta and Refuse.—Where a sewerage system has not been laid, there is probably no better method of disposing of the excreta in the tropics, either in camp or barracks, than by the use of the Smith crematory, already described. Next in desirability comes the trough and odorless excavator system; following which the use of dry-earth closets may be employed. Where the latter is in operation, sheds for the storing of dry earth should be provided for use during the rainy season. The primitive system of privy pits can never be accepted by military hygiene, least of all under tropical conditions. Where cess-pits already exist in houses or barracks to be occupied by troops, these should be thoroughly cleansed, limed, filled with fresh earth and sealed over with cement. Soil-contamination by urine should be guarded against, and night-tubs or other convenient facilities for its reception should be provided. The disposition of garbage and refuse should be scrupulously carried out in the manner already described. Where natives are employed to do work of a sanitary nature, they must be carefully watched, since they are generally not thorough in their methods.

Cleanliness.—Bathing of the person is particularly necessary in the tropics, to maintain the proper function of the skin and remove perspiration. Ample shower-bath facilities should be provided, and each man should be required to bathe himself at least three times weekly. Discipline, however, will not usually be required to make the United States soldier bathe in tropical climates, since the cool bath is grateful not only during intense and relaxing heat but serves as a stimulus to the appetite and a tonic to mind and body. Where a special reaction of the skin is desired, a few slices of fresh limes may be added to the sponge-bath. Bathing is best performed, in the tropics, shortly before the second meal of the day, and this can usually be accomplished. Sea-bathing is excellent, but should not be carried out when the sun is high. The waters of many tropical streams contain various parasites and may perhaps serve as a means for the occurrence of malarial infection, but bathing in clear running streams is not objectionable.

In the tropics, it is necessary for comfort and health that the undergarments be frequently changed and washed. Unfortunately the methods employed by the native laundresses for securing the cleanliness of clothing are extremely unsanitary, and the dirt is pounded out with clubs in the nearest water-course, however polluted it may be. The garments are then spread on the ground to dry and are kept sprinkled until bleached. This practice is undoubtedly a factor of no mean importance in the prevalence of skin diseases; particularly with regard to the so-called "dhobie itch," which is so prevalent in the tropics. It is probable, also, that contagious diseases and insect parasites are largely disseminated through the unsanitary habits and surroundings of the native laundresses. Hence it is important, at all tropical stations, that steam or other laundries should be established for the benefit of troops, in which clothing may be properly boiled, washed in pure water and dried by steam or on lines and not on the ground. Such laundries should be under official control and should be frequently inspected.

Habits.—In the tropics, the mind as well as the body should be exercised. Intellectual stagnation is as much to be avoided as physical torpor, and nothing is so likely to prevent irregular habits and resulting disease

as well-ordered mental employment. During one season of the year, the enforced restraint, the never-ending downpour of rain, the dull and leaden sky, the sad and depressing influence of dark and gloomy days are all combined against the soldier to create nostalgia, *ennui* and discontent. Conditions of this sort are particularly trying to men of active brain quality and nervous temperament, and such are not unlikely to resort to stimulants when weary, restless and fretted. Hence it is of special importance, in addition to the imposition of light duties, that suitable sheltered spaces be provided for the recreation of the men and that every means be taken to secure their amusement. It is much to be desired that soldiers on tropical service should find pleasant means of passing the time within the limits of their own command; for much communication with neighboring towns, with their ever-present incentives to vice, drunkenness and disorder, is to be avoided. Troops should be governed with a light but firm hand, and rigid discipline should be maintained. The number of native camp followers within the limits of military control, particularly females, should be reduced to the limits of strict necessity.

The free use of alcoholics, always inadvisable, becomes a source of great danger in the tropics, particularly to young men and to the unacclimated. Hard drinking is notoriously a predisposing cause of liver disease in India, and its depressant effects are sooner manifested and much more marked in degree in a hot climate than in more temperate regions. This latter point is particularly well demonstrated by the medical statistics of the British army, stationed as it is at points all over the world, in the temperate zones and in the tropics; since it may fairly be presumed that the habits of the British soldier, with respect to the use of alcoholics, do not change to any special extent as he is moved from station to station. The rates for alcoholism and its results, at the various stations of the British army, are as follows:

Place.	Year 1897, Ratio per 1,000 Strength.			Decade 1887–96, Ratio per 1,000 Strength.		
	Admissions to hospital.	Deaths.	Constantly non-effective.	Admissions to hospital.	Deaths.	Constantly non-effective.
England	1.7	0.01	0.06	2.3	0.04	0.08
Scotland	1.9	.04	.05	2.8	....	.06
Ireland	1.4	.04	.05	2	.02	.06
Canada	3.7	....	.07	3.2	....	.09
South Africa	.4	....	.03	3	.03	.08
Gibraltar	8.9	....	.37	5	.02	.18
Bermuda	11.2	....	.30	9.1	....	.29
West Indies	15.6	.74	.32	7.8	.08	.19
Mauritius	14.5	....	1.82	20	....	1.20
Ceylon	4.5	....	.12	4.8	.08	.17
China	6.4	....	.34	3.2	.15	.16
Straits Settlements	3.	....	.07	6.2	.08	.27
India	5.2	.03	.22	7.4	.07	.24

On averaging together the above figures, it is seen that for the five stations in the temperate zone—England, Scotland, Ireland, Canada and South Africa—the ratio of admissions for alcoholism in 1897, per 1,000 strength, was 1.8; the death-rate from alcoholism was .018 and the constant ineffectiveness from the same cause was .052. For the stations in

hot and tropical climates—Gibraltar, Bermuda, West Indies, Mauritius, Ceylon, China, India and Straits Settlements—the admission rate for alcoholism during the same year was 8.68 per 1,000, the death rate from the same cause was .09 and the constant non-efficiency was .445. For the decade 1887–96, the rates per 1,000 were: For cold climates 2.64, .016 and .072; for hot climates 7.93, .06 and .337. These results are extremely interesting, since they show that not only do four times as many British soldiers require treatment in the tropics for alcoholism as do in temperate climates, but also that the death rate from alcoholism is more than four times greater in hot climates than in the temperate zone. Full data as to the relative influence of alcohol in producing inefficiency among United States troops serving in the tropics and at home stations, under similar conditions, are not as yet available; but the report of the surgeon-general of the United States army for 1899, which gives deaths alone, shows that during the period May, 1898, to June, 1899, inclusive, the death rate from alcoholism was .14 per 1,000 among troops serving in the United States and .296 for troops serving in Cuba, Porto Rico and the islands of the Pacific—or more than twice as high in the tropics as in temperate regions. If it be objected that soldiers actually drink less in the tropics, then the above figures for the troops of Great Britain and the United States should obviously be increased to correspond with the deficiency in the alcohol used; if the soldier is said to drink more liquor in the tropics than in a cool climate, the evil results of such excessive drinking are shown by the above figures. In either case, the claim advanced by some that the use of alcohol is desirable in the tropics is refuted beyond the possibility of discussion. Further instances showing the influence of alcohol in impairing military efficiency in hot climates have been given in the preceding chapter.

Much as moderation in eating is desirable in the tropics, moderation in the use of alcohol is obviously even more necessary. If the use of alcoholic liquors is persisted in despite due warning, these should preferably be taken with food and the pernicious habit of constantly taking small quantities should be avoided. As to the character of the beverages used, there is little doubt but that good claret, taken with water, is the least harmful —the other light wines coming second. Beer, in the tropics, is distaseful to many and provocative of bilious disorders. Spirits, particularly those of native production, are above all the most injurious, and the great dangers attending their use should be impressed upon the men. It is of interest to note that both wine and rum, in considerable quantities, are included in the rations of the French and Spanish soldiers serving in the tropics. In the British army, however, the soldier is now rarely allowed the ration of spirits, when on campaign in the tropics, to which he is entitled on field service in temperate climates. This deprivation was the result of earnest representations on the part of observing officers, both line and medical; and the reports of the medical officers accompanying subsequent expeditions have been uniformly enthusiastic in favor of the substitution of tea for alcoholics. There are probably times, however, as during extraordinary labor under malarious conditions, when a little alcohol may be taken with advantage.

As regards sexual gratification by new arrivals, there should be a special word of warning. The habits of heat production, so necessary for protec-

tive purposes in a temperate climate, appear to be retained by the organism through its preliminary period of acclimation, even though not needed in the tropics. The genital function appears to be increased, while the lassitude incident to the tropics prevents the accustomed amount of exercise and so discourages the dissipation of excessive physical energy by other means. The result is a greatly heightened and exaggerated *nisus generativus*. Excesses in venery are especially trying to the unacclimated, yet the character of the lower-class women of the tropics is apt to be such that opportunities are not wanting for the gratification of passion. While always vexatious, the allied questions of venereal disease and prostitution become, in the tropics, a problem manifestly difficult of solution. On the one hand are a large number of young men of largely undeveloped and unstable character, surrounded by constant temptations to venery and at the age when animal instincts are at their maximum. On the other hand, there is a large native population in which fornication is not regarded as a moral offence but as almost a legitimate calling; and in whom, at least with the class willing to consort with the soldier, venereal disease is much more common than among the corresponding classes in temperate climates. "The hard fact remains that among a body of men, mostly very young and nearly all, by the conditions of the service, obliged to remain unmarried, removed from home ties and restraints into a country where climate and environment conduce to sexual indulgence, comparatively few are able to control the strongest passion in human nature—and with disastrous results." This, while written with respect to the British troops in India, applies with almost equal force to the soldiers of other nations serving within the tropics.

General Precautions.—Chilling is not less dangerous than exposure to the direct solar rays. As the skin is constantly moist with perspiration, exposure to a current of air will rapidly induce great reduction of surface temperature, and this, while not necessarily dangerous, becomes so if the vital resistance be lowered from exhaustion or debility. If forced to remain quiet while bathed with perspiration, exposure to drafts should be avoided and, if possible, some additional clothing should be donned. In the arrangement of squad-rooms the beds should be so located that no air-currents can pass directly over the sleepers. For the furtherance of this purpose, screens and latticed blinds will come into requisition.

Exposure to rain-storms should, when possible, be avoided. Parke states, with reference to his travels in equatorial Africa, that "every one who got a wetting either by rain or by submersion in a lake or river, or who was exposed to a chilly breeze after perspiration, developed fever as an immediate consequence. Beasts as well as men suffered. The inference is obvious." Wetting and chilling are also well recognized as predisposing causes of dysentery and intestinal disorders. Wet clothing should be promptly changed; the body being bathed with tepid water and rubbed briskly with a towel before putting on dry garments. If a change of clothing is not available, the individual should keep active until dry; and under no circumstances, where the opposite is possible, should damp garments be slept in. If troops are unavoidably exposed to continued wet weather, the administration of prophylactic doses of quinine may be advisable in malarious localities.

In the tropics, great attention must be paid to the state of the bowels. Constipation is the usual effect of prolonged residence in a hot climate—because of the fact that insufficient exercise is usually taken and it is not always easy to get suitable fresh vegetables and vary the diet, because of the prevalent malarial conditions by which the liver is rendered inactive in its functions, but chiefly through the attraction of systemic fluids to the surface and their loss by perspiration. On the other hand, chilling or indiscretions in diet are usually followed by diarrhoea and intestinal disorders. In all extremely malarious countries, a small prophylactic dose of quinine —about five grains—should be administered daily, preferably just before the evening meal. The routine use of quinine in all parts of the tropics, without special indications for its use, is, however, undesirable.

It often happens that sickness is produced by very slight indiscretions. Young soldiers in the vigor of present health are apt to disregard proper precautions for its preservation, but they may rest assured that the importance of the latter is not over-estimated and that any intemperance of habit, indiscretion in diet, or such apparently small things as a brief exposure of the head to a hot sun or the laying aside of underclothing during a stifling night may lay the foundation of serious mischief. On the other hand, nothing is worse for troops in unhealthful localities or in time of epidemic disease than a state of nervous expectancy or apprehension—a condition as unwholesome as it is unmanly.

Change of Climate.—The advantages of change of air in the tropics have been established by long experience; and special camps or stations, to which troops are moved during the unhealthy season, are used in the colonial services of France and England and were formerly employed by Spain. Altitude in the tropics reproduces to a less degree the advantages of cold climates, and hence it is frequently advisable periodically to abandon the coast and low plains for a sojourn in the mountains. In general, the height selected should be greater than fifteen hundred feet but need not exceed three thousand feet. For practical purposes, it may be considered that each thousand feet of altitude lowers the average temperature about four degrees, but this rule is subject to slight variations.

While it not infrequently happens that individuals may live in the tropics for long periods apparently unaffected by the heat and climatic conditions, it is none the less true that troops recruited in temperate climates, as a whole, are ultimately debilitated by such conditions and and require transfer to cooler stations. The period at the end of which such change becomes necessary naturally varies according to the unhealthfulness of the locality; but under no circumstances should white troops be kept in the tropics for a period longer than four years. The French limit the tour of service in Annam and Tonquin to two years, this period is undoubtedly somewhat long for the more insalubrious regions. It is stated that the Belgian forces on the Congo and the British white troops on the west coast of Africa are rotated yearly. For our own service, experience has shown that troops are so debilitated by service in the Philippines that to require a period of service longer than two years is inadvisable. For those seriously affected with such tropical diseases as malaria and dysentery, repatriation affords by far the best prospect of recovery.

II.

THE HYGIENE OF COLD CLIMATES.

With proper precautions, intense cold is better supported by troops recruited in the temperate zone than is tropical heat. The low temperatures of the far north are healthful; this being largely due to the small number of pathogenic micro-organisms capable of maintaining an existence under such conditions. It has long been noted that travelers in the circumpolar regions are unusually free from infectious disease, and Nordenskjold is authority for the statement that Spitzbergen, in summer, is the most healthy spot on earth. Levin has recently made a number of bacteriological examinations of air in Spitzbergen and King Charlesland, a minimum of 1,800 liters of air being filtered for each examination. In only one instance were bacteria found, the sample of air in that case being taken above the deck of a vessel—and as only three colonies developed in this instance, it is a question whether a particle of dust from the ship did not get into the gelatin. On the other hand, all samples of water, whether taken from the sea, from glaciers or obtained by melting snow or ice, were found to contain bacteria in small numbers. In samples taken from the surface of the sea, Levin found only one micro-organism for each 11 c.c. of water—a proportion of germ-life which is absolutely insignificant in view of the fact that the same amount of water taken from the Seine below Paris has been found to contain more than 2,000,000 bacteria. It is interesting to note that the same investigator found the intestinal contents of various Arctic animals and birds to be entirely free from micro-organisms; thus demonstrating that the presence of bacteria is not indispensable to the processes of digestion.

In the consideration of the direct effects produced by cold, it must be borne in mind that actual temperature is not the only factor to be taken into account; dryness and stillness of the air permitting a much lower temperature to be borne without discomfort than when the air is damp or in motion, while even a moderate wind will render a low temperature unbearable. Not only does much depend upon the degree of cold, but also upon the duration of exposure and the medium or manner of application; and to these conditions may be added the extent of surface exposed and the general health or physiological condition of the individual. The great degree of cold which inhabitants of temperate climates can bear without ill effects is well shown by the experience of Arctic voyagers, Parry noting a temperature of —55° F., Franklin of —58° F., and Back of —70° F., or 102° F. below the freezing-point. Even within the limits of the United States, a degree of cold equal to that attained in the Arctic regions is often experienced during the bitter winters of the northwest; the lowest temperature ever recorded in the United States being noted at the now abandoned military post of Camp Poplar River, in eastern Montana, when the thermometer was said to have registered —64° F. In the central portion of Alaska, where a number of garrisons are at present maintained, all the rigors of the Arctic prevail; the winter temperature approximating that of southern Greenland. From these

latter facts, the special measures calculated to promote the welfare and efficiency of troops serving in very cold climates may be briefly considered.

In cold climates, according to Catat, the respiratory function is impaired. Reasoning from the conditions already shown to exist in the tropics as compared with temperate climates, the rapidity of respiration should be increased while the volume of respired air is diminished. Turner states that great cold reduces bodily temperature and diminishes the force and frequency of the heart beats; Catat noting that the pulse of the adult Greenlander is often no higher than forty beats per minute. The appetite is greatly increased and visceral secretions are abundant, due to constriction of the superficial capillaries and the absence of sensible perspiration. The digestive and metabolic functions are proportionately active to the increased amount of food required. Cutaneous sensibility is much diminished, but the sensory organs appear to take on a condition of extreme acuteness. During winter there is a constant tendency to sleep, a condition of irritability alternating with apathy, and often melancholia, hallucinations and delirium. Payer states that the men "acquire an uncertain gait, like that of a drunken man." Moderate cold, and very severe cold when acting through no very great period, undoubtedly exercises a tonic and stimulating influence upon the organism; but intense cold, particularly when prolonged, is markedly depressant.

The temperament best suited to service in the far north is that known as the sanguine; individuals of this character being endowed with a more vigorous power of assimilation, active circulation, florid skin, moderate deposits of fat, large and firm muscles and the capacity for brisk movements and prolonged exertion. A notable quality generally possessed by this class is a superior power of producing animal heat under low temperatures; justly esteemed by Ross as being of the first importance in those serving in high latitudes. This heat-producing power, however, is possessed in varying degree by different persons, even if of like vigorous organization; a degree of extreme cold being merely invigorating to one, while it might produce painful or exhausting depression in another. Unfortunately there is no ready test to determine the existence of this desirable quality in recruits, yet it may be safely asserted that it is possessed by northern peoples—Norwegians, Danes, Swedes, Canadians, New Englanders and inhabitants of our northern states—in greater degree than by those from the south; and by the white race better than those of darker skin. Natives of the tropics soon succumb under conditions depending upon the more rigorous climate of colder countries, and Baudin cites the example of an English regiment composed of West Indian blacks, which, in 1817, was sent to garrison the comparatively mild station of Gibraltar, with the result that it was almost entirely destroyed by tuberculosis in fifteen months. In France, according to Laveran, similar conditions have been observed among the convicts at Brest, some of whom are negroes from the colonies; disease, especially tuberculosis, making frightful inroads among the latter class and four-fifths of them being said to die annually. Among the military forces of the United States, the negro troops appear to possess an extremely great susceptibility to the action of cold as compared with white soldiers. Thus for the decade 1879–88, the admission rates for frost-bite, per 1,000 strength, were 6.33 for whites and 27.46 for colored troops;

while for the year 1889, the rates were 3.32 for whites and 27.32 among the colored. This great difference between the two races, in respect to susceptibility to cold, is even more significant when it is remembered that the negro regiments are chiefly recruited in the more northern states—since the fact that natives of warm countries are unable to resist great cold is too well recognized to require argument. The negro troops themselves dislike service at cold stations, and it very frequently happens that where such soldiers are discharged by expiration of term of service from regiments stationed in Montana or Dakota, they refuse to re-enlist in their former organizations but proceed at their own expense, for that purpose, to colored regiments serving in the southern part of the country. It would thus appear to be advisable, as far as practicable, to recruit for northern service from comparatively cold climates and from white persons of the type and physical character above described. For cold climates, as for the tropics, troops should be mature and well developed.



FIG. 382.—Arctic Overshoe.

With regard to clothing, for service in the cold weather of the far north it is essential that the underwear, particularly that worn next the skin, be made of woolen; and for such conditions the heaviest underclothing at present issued is insufficient. For troops serving in such climates, an even heavier grade should be furnished, and for this purpose nothing is superior to the loosely woven Jaeger underwear. During winter marches or expeditions, much warmth and comfort will be derived from the use of a wide flannel bandage encircling the abdomen. Too much care cannot be given to the protection of the feet, the parts usually first to suffer from frost-bite. One of the best arrangements for the avoidance of this accident consists in the use of heavy, soft, woolen stockings over which, together with the trousers, the so-called German socks, heavy and reaching to the knees, are drawn. The foot should then be encased in loose moccasins and Arctic overshoes put on over the whole. Shoes made throughout of heavy felt afford excellent protection against a high degree of cold and are both light and comfortable. They are, however, quite costly, and are not sufficiently durable to meet the needs of the military service where much marching is to be done. Further, they are totally unfit for service during thaws or when the snow is damp, since they readily absorb and retain moisture. During intense cold, the use of leather about the feet greatly favors frost-bite, and the foot-wear must be sufficiently loose so as not to interfere with circulation. The outer clothing should be made of heavy kersey or blanket-cloth and should be loose so as not to interfere with the circulation or muscular action. Many hunters and explorers use suits of buckskin or chamois over the underwear, but these soon lose their pliability. A thick woolen sweater would be a most comfortable



FIG. 383.—Canvas Overcoat, Blanket-lined.

addition to the uniform in cold climates. Until recently, troops at the colder stations were supplied with overcoats of buffalo fur; but the supply of these is now practically exhausted and canvas overcoats, lined with heavy blanketing, are issued in their place. These are almost as warm as the fur overcoats and are much lighter, more pliable and closely fitting. The canvas, however, becomes extremely cold to the touch during low temperatures, and to minimize this defect it is necessary that the collar and cuffs be well faced with woolen material. The present method of fastening this coat, with buttons and loops, is inferior to the use of light snap-hooks and rings, for ease in fastening and unfastening with benumbed fingers. For winter exploring or sledging expeditions within the Arctic circle, the outer garments should be of fur and fashioned according to the style of the Esquimaux. For the protection of the head, two kinds of head-gear are supplied. A cap of muskrat fur is much liked by the troops and affords sufficient warmth and protection for ordinary conditions. It lacks, however, a chin-piece, and does not sufficiently protect the lower part of the face when marching against head-winds. A canvas cap, lined with flannel and having a chin and neck protector, is also issued at the colder stations. If made out of muskrat fur, it could scarcely be improved upon for military use where exposure to intense cold is required. Arctic explorers find the use of some protection for the nose to be essential, and for this purpose the face-cloth or nose-cover is much used. The muskrat fur gauntlets lined with flannel, furnished for use in cold climates, are warm, comfortable and deservedly popular among troops. A canvas mitten lined with heavy flannel is also authorized, but has not been issued to any great extent. Mittens are much warmer than gloves, and for expeditions in very cold climates the use of mittens, made of fur, is preferable. For military use, the method employed by the Russians to prevent the loss of the hand-coverings —each being fastened to the end of a tape passed through the coat-sleeves—is advisable. With the clothing just described, troops will be well protected under almost any conditions of temperature. Its provision is a matter of comparatively recent accomplishment, and Woodhull states that prior to its issue as much as fifteen per cent. of the troops at some of the stations in the northwest were incapacitated for duty, during severe weather, as a result of frost-bite.



FIG. 384.—Uniform Fur Cap.



FIG. 385.—Canvas Cap, Blanket-lined.

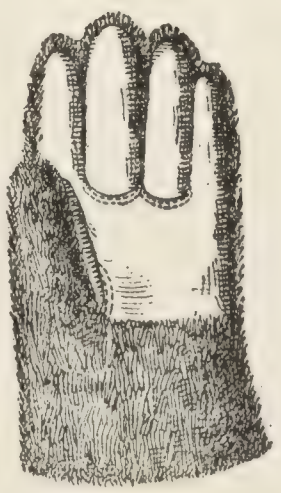


FIG. 386.—Fur Gauntlet.

Next to the clothing, the sanitary precautions above all others in importance, for those sojourning in high latitudes, relate to the food supply. Deficiency in quality and quantity of food is sure to impair the strength of the men, favor the action of cold and invite disease; especially when conjoined with deficient sunlight, dampness, impure air, low temperature, defective cleanliness and want of

exercise. As to quantity, Franklin, speaking of food and clothing as supplementing each other during polar cold, says: "During the whole of our march we experienced that no quantity of clothing could keep us warm while we fasted, but on those occasions when we were able to go to bed with full stomachs we passed the night in a warm and comfortable manner." And Ross wrote: "He who is well fed resists cold better than the man who is stinted, while starvation from cold follows but too soon on starvation in food. In every expedition or voyage to a polar region the quantity of food should be increased, be that as inconvenient as it may. It would be desirable that men could acquire the taste of Greenland food, while all experience has shown that the large use of oil and fat meats is the true secret of life in these frozen regions."

According to Dalton, the amount of food necessary for a man in full health and exercising in the open air, for the temperate zone, equals about 2.41 pounds of solids and 3.38 pounds of liquids—or about one-twenty-fifth of the body-weight. These amounts, however, have been shown by experience to be quite insufficient in Arctic climates—where the loss of heat is great and oxidation goes on rapidly—and fall far short of the ordinary diet of the native, which may undoubtedly be taken as a criterion, to a considerable extent, of the needs of the system under conditions of extreme cold. Ross states that an Esquimaux frequently eats as much as 20 pounds of flesh and oil daily. Parry's test of the appetite of an Esquimaux for a single meal was 8.5 pounds of meat and 1.75 pounds of bread, water not being counted, and the quantity was not considered extraordinary. In another instance, he gave to a young Esquimaux 10.25 pounds of solids, 9 pints of water, 1.25 pints of soup, 3.5 glasses of raw spirits and a tumblerful of strong grog. In yet another instance, the subject ate of solids at a single sitting:

	Lbs.	Oz.
Bread dust and train oil	1	10
Walrus flesh, boiled	7	1
Seal and bread	1	0
Two tallow candles	0	3
Bread and butter	0	1
Total	9	15

At the same meal the subject drank two quarts of rich walrus soup and four quarts of water. Simpson states that a Yakut ate 9 pounds of beef and 4.5 pounds of butter within an hour; and Hayes says: "I have frequently seen an Esquimaux eat from 6 to 12 pounds of meat, one-third of which was fat, and I should place the daily consumption of the men at from 12 to 15 pounds." Kane wrote: "I should average the Esquimaux ration at 8 or 10 pounds a day, with soup to the extent of half a gallon." Such quantities of food are not considered by the authorities quoted as representing the extremes; and using these observations in connection with the fact that the amount of food ordinarily sufficient in the temperate zone is quite inadequate to support the system and supply the necessary heat in the Arctic, and that the explorer instinctively approximates his diet in both character and quantity to that of the native, it is safe to say that the daily increment of food for very cold climates should be equal to one-twentieth of the body weight—varied according to the isothermal lines—and that half the material so taken should be dry solids.

In character, the best foods for cold climates are those concentrated forms which are readily and easily transformed into heat, and these are the kinds which are provided by nature in the abundant animal life to be found along the Arctic littoral. Fats are especially craved and are taken in large quantities, the northern explorer promptly adopting the practice of the native in this respect. Kane says: "Our journeys have taught us the wisdom of the Esquimaux appetite and there are few among us who do not relish a slice of raw blubber or a chunk of frozen walrus beef. The liver of a walrus, eaten with little slices of his fat, of a verity is a delicious morsel." Fresh meat should be used wherever obtainable and needs no special means of preservation so long as the temperature remains below the freezing-point. Where scurvy is to be dreaded, the meat should be eaten underdone; and Kane recommends the use of raw flesh for this purpose, which, when frozen, he states is not at all distasteful to the civilized palate. No opportunity for securing fresh animal food should be lost by scouting or sledging parties, for the use of preserved meats in excess, except pemmican, is injurious and promotive of mal-nutrition and scurvy.

From what has been said, it would appear that the present ration of our service is insufficient and improperly constituted for the use of troops serving at stations near or within the Arctic Circle. While sufficient data are not available to permit of accurate calculations on this point, it is undoubtedly true that an increase of at least one-half in the meat components of the ration—particularly bacon or pork—would be of great advantage, and that, under conditions where great hardship and cold are to be undergone, this amount should be still further augmented.

With the fats and proteid, a certain proportion of carbohydrates should be supplied, especially in the form of bread and dried or preserved fruits. Vegetables are essential, either dried, fresh or canned. In their absence, the natives of northern climates supplement their meat diet whenever possible by the use of angelica, dandelion, sorrel and bilberries; also by the contents of the stomachs of the reindeer, caribou, moose and musk-ox, these consisting of fine mosses and grasses in a partially digested condition. Fresh potatoes can be preserved any length of time for use under such conditions of climate by being covered with black molasses after being cleaned, pared and cut into small cubes. After washing, the taste and texture of the tuber remain. On board whaling and exploring ships, it is customary to germinate large quantities of seeds by the heat of the stoves and use the sprouts thus produced as vegetables. This could readily be done by troops stationed in the interior of Alaska and would often be of service. Where an abundance of fresh meat and vegetables is not available, the daily issue of an ounce of lime-juice is advisable for the prevention of scurvy. Acid wines and home-made beers are also valuable for this purpose, but spirituous liquors diminish the power of resistance to cold and their use is obviously dangerous.

Tea is the favorite beverage in cold climates and is drunk hot in large quantities. The eating of snow to quench thirst should be avoided.

While sledging expeditions in the Arctic have been exposed, without suffering, to continuous cold of as great a degree as $-50°$ F., soldiers, on the other hand, have often been known to succumb to cold in comparatively warm climates and at a time when the thermometer registered by no means

a very low temperature. It may fairly be considered that accidents from this cause are relatively more frequent in the cold weather of temperate climates than in that of the far north, probably because of the greater precautions taken for the conservation of the body-heat under the latter conditions.

Since the famous retreat of the Ten Thousand when a rigorous climate destroyed more Greek soldiers than did the Persians, great cold has frequently exerted a strong influence upon military operations. Voltaire states that in the winter of 1709 a large part of the army of Charles XII. was destroyed by cold, 2,000 men being frozen to death during one march. In 1719, 7,000 Swedes, on their way to the siege of Drontheim, perished in the mountains between Sweden and Norway; while in 1742, in the retreat from Prague, 4,000 French soldiers died from cold and want. The sufferings of our own troops at Valley Forge are a matter of history; and in the destruction of Napoleon's army in Russia, cold was by far the greatest factor. During the Crimean War, according to Viry, there were 5,290 cases of frost-bite with 1,179 deaths among the French troops; while among the English forces there were 2,852 congelations with 463 deaths. Laveran states that during the winter of 1870–71, freezing of the feet caused much suffering in the French army and there were many deaths from cold. In 1879, according to the same authority, a column of 755 men in the mountains of Algeria, at the end of the month of March, had 60 cases of frost-bite, of which 19 proved fatal. In our own service, for the decade 1888–97, the influence of cold on a constant strength of about 24,000 men was as follows:

Year.	Cases.	Deaths.	Discharges.	Year.	Cases.	Deaths.	Discharges.
1888.....	141	....	5	1894.....	58	....	1
1889.....	34	....	2	1895.....	54	....	..
1890.....	60	....	1	1896.....	47	....	..
1891.....	62	....	..	1897.....	59	....	2
1892.....	66	....	1				
1893.....	67	....	1	Total	648	....	13

It should be remembered, however, that of the United States forces but a small part was stationed in regions where frost-bite was liable to occur, and hence the cases reported necessarily related to a comparatively small fraction of the whole army.

The history of congelation in armies shows that a state of low vital resistance, brought about by unfavorable hygienic conditions, plays almost as important a rôle as that of cold itself, and it is a matter of common observation that accidents from freezing occur far more frequently among such soldiers as are weakened by fatigue, sickness and privation. During the Crimean War, the temperature was never very low, and a report of the time suggests that the large number of congelations observed among the soldiers might justly be regarded as "gangrene owing to scorbutic tendency exaggerated by cold." On the other hand, troops which are well fed and warmly clad resist the most intense cold without injury, as has been repeatedly shown in our winter campaigns against the Indians of the northwest. In the Powder River expedition of 1876, conducted during the three winter months, and with the mercury never above freezing and often down

to —40° F., Rosse states that in a force of about 2,000 men but 31 cases of frost-bite were reported, while no cases were reported among the 350 Indians with the command. During the winter of 1891–92, when about 6,000 troops were constantly in the field against hostile Sioux, only 62 cases of congelation occurred.

The phenomena which precede the death of the soldier from cold, while on the march, are well described by Larrey: "The dangerous condition is shown in the pallor of the face, by a kind of idiocy, by difficulty in speaking, by feebleness of vision or perhaps total loss of that sense, and in that state they march for a greater or less length of time, conducted by their comrades or friends; the muscular action is weak and the individual totters on his legs like a drunken man. This weakness is progressive and is a certain sign of the extinction of life. Separated from the column and abandoned to themselves, they soon lost their balance, fell into ditches covered with snow, a state of lethargy ensued and a few moments terminated their miserable existence." There is sometimes muscular contraction during freezing, particularly of the neck muscles, together with symptoms like those of catalepsy. According to Forestius, soldiers have been found frozen and standing with arms in their hands—and the same thing was observed by Larrey during the retreat from Moscow.

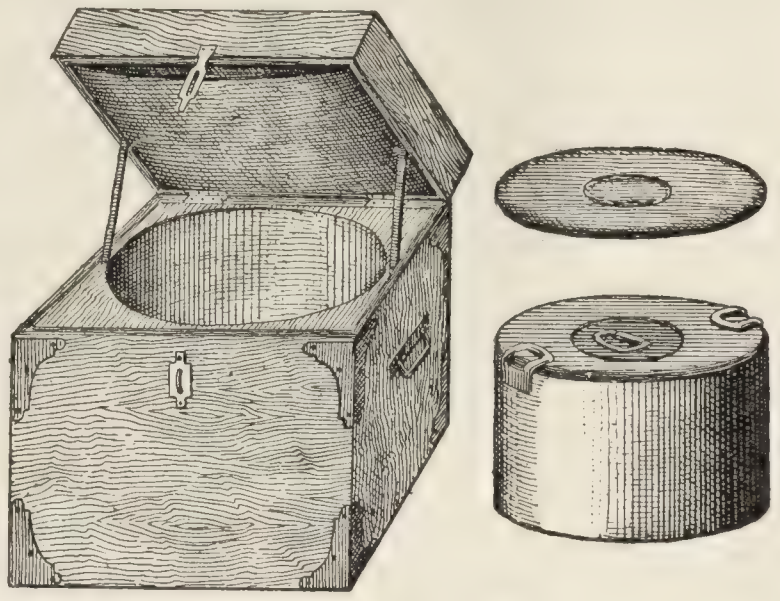


FIG. 387.—Norwegian Stove.

In the prevention of congelation, an abundance of nutritious food is only second in importance to sufficient and proper clothing. The extremities are usually the main points of attack, owing to their relatively poor protection and distance from the main sources of systemic heat. The feet are particularly susceptible to frost-bite, a fact showing the necessity of warm protection and water-tight, loose and comfortable foot-wear. To protect the hands, heavy gloves or mittens are essential, the latter being preferable. It is of advantage in diminishing the effects of cold upon exposed surfaces, such as the face, particularly in the case of driving snow-storms, thoroughly to anoint the parts with some greasy substance, as the fat of beef, pork or mutton, or vaseline. Whenever possible, hot food or drink should be served out to troops on the march; and this may be accomplished without the delay incident to building fires by the use of the so-called Norwegian stove—an apparatus readily improvised from an ordinary camp-kettle fitted into a thick felt covering. With this arrangement, the soup or stew is raised to the boiling-point, removed from the fire, the kettle inserted into the felt sheath and the whole carried with the column. The process of stewing continues automatically, and even after several hours' marching in the cold the temperature of the soup does not fall below 100° F. This method has been used with much success with moving commands in the Russian and Austrian services. If a march must be made in ex-

tremely cold weather, it should be concluded as soon as possible without undue fatigue; the ranks being well closed up and no one allowed to leave the column. In general, however, if an army is well fed, well clothed and free from sickness, it can undertake a winter campaign with perfect safety if the distances to be marched are not too long. Where frost-bite has actually occurred, the treatment consists in the prompt friction of the affected part with snow or brisk rubbing when immersed in ice and water. Only after reaction is fairly established, should the sufferer be allowed to enter a warm room or approach a fire.

The glare of bright sunlight upon fields of snow produces the condition known as snow-blindness, particularly when troops are subject to prolonged marching toward the end of winter or in the early spring of the high latitudes. Since, in our service, soldiers are ordinarily housed in barracks during cold weather, the admission rate for this cause is usually low—only three or four cases per annum—but in the winter of 1890–91 there were 133 admissions to sick report from this cause; chiefly among the 6,000 troops engaged in that year in the campaign against the Sioux of the northwest. In the month of March, 1894, of a company about fifty strong, marching a distance of about sixty miles during a period of three days, nearly all were incapacitated for duty by reason of snow-blindness. This condition may be usually prevented among soldiers by smearing the eyelids and upper part of the cheeks with a mixture of charcoal and grease; but where exposure to the glare is constant, as in the sledging parties of the far north, further protection is necessary. For this purpose, dark goggles, fitted in frames covered with chamois skin, have been recommended. The "snow-eyes" of the Esquimaux are made of light wood with a bridge resting on the nose, like spectacles, and presenting narrow transverse slits for the passage of light. These are said to be superior to goggles as a protection against glare, and are not liable to the accident of fracture. Under any circumstances, if snow-blindness is to be apprehended, the men should be marched in close column and each soldier directed to keep his eyes upon the dark clothing of the man in front of him—the leading rank being frequently changed to the rear.

Guard duty is particularly dangerous during cold weather, and sentinels should be kept on post not more than an hour at a time; or a running guard may be established. When relieved from sentry-duty, the soldier should not be permitted to lie down at once but should be required to pace briskly around the fires until numbness has worn off. Under stress of severe weather, men should be told off to keep up the fires.

If forced to bivouac on snow-covered ground, the piling up of snow around the men will afford great protection from cold winds, and, with a fire in the center of each cleared space, properly clothed troops, except in the severest weather, will sleep without much danger of freezing and often not uncomfortably. In the absence of other shelter, during very low temperatures, excellent temporary protection against the cold may be made from large blocks of snow cut from well-packed drifts—or the drifts themselves may be burrowed into by the men.

Where canvas shelters are used in cold climates, the wall tent will be found superior to the conical tent on account of the height of the latter and consequent greater difficulty in heating. The tent for service of this

character should be made of double thicknesses of canvas, sewed together at the edges and quilted at suitable intervals to divide the intervening air-space into small sections and thus prevent the establishment of too great movement of air in this insulating space. The sod-cloth should be made in two flaps; one being turned inside the tent as at present, while the other flap extends around the outside of the tent and is heaped with snow to serve as a wind-break and partially take the place of tent pins, always difficult to drive in frozen ground. Small apertures at the junction of the outer sod-cloth and wall are left to allow of the driving of such pins as may be necessary. The end of this tent, instead of being slit down the center to form the door, should be formed of overlapping canvas, giving a "double-breasted" effect, extending completely over one-half of the end and two-thirds of the distance to the wall on the other side; the ends of this canvas being provided with grommets and rings for fastening. The doorway of this tent is thus brought to the outer third of each half of the end, the aperture varying from one to the other side according as one or the other canvas-flap is drawn externally. The outer flap is now pegged at its end to a distance of several feet away from the tent. The windward flap is always made the external one, and in this way a sheltered valvular doorway, perfectly protected against wind or snow, is provided. Should the wind change to the opposite direction, the flaps are readily reversed. If additional tent-space is desired, both flaps can be brought together, buttoned at the edges and stretched tightly by a peg and guy rope at the corners; the capacity of the wall tent being increased nearly one-half by this method. This pattern of tent was proposed by the writer during the winter of 1899–1900. Its advantages as to warmth and shelter, as compared with the present tent, are obvious. For more permanent habitations, heavy log-houses, well chinked, will be found comfortable; or tight frame structures made with double or triple walls and enclosing dead-air spaces, built on the principle of the cold-storage buildings already described, will be in every way satisfactory. The doors and window-spaces should not be too large, and for very cold climates the latter should be provided with triple sashes. The action of great cold has a direct effect upon ventilation by causing troops tightly to seal up their quarters; the foul air thus engendered undoubtedly playing an important part in the genesis of scurvy as well as other diseases. Hence every care should be given to the provision of a suitable means of ventilation; but this is a difficult matter and one to be accomplished only with the loss of a considerable amount of heat. It may be here remarked, however, that it is neither necessary nor desirable to raise the temperature of habitations too high in climates of this character. One not exceeding 55° F. is perfectly compatible with health and comfort and at the same time the inconvenient condensation of body moisture, produced in greater quantity at higher temperatures, is largely avoided. This condensation of moisture is a matter of such importance under these conditions that it is reported of the Arctic voyage of the exploring ship *Alert* that the covered spaces under the bunks became filled with ice from the body-moisture of the occupants before the condition was discovered; while the amount of frozen moisture removed from the well, through which air made its escape from the cabin of the ship, amounted to as much as a bushel in the twenty-four hours.

For bedding in the field, in the far north, nothing is better than the sleeping-bag. This is usually of canvas, lined with one or more thicknesses of felt or furs, and is not only warm in any weather but wind and moisture-proof. While the use of sleeping-bags is probably not practicable in the case of large bodies of men, they should always be provided for small expeditions. Weight for weight, they afford much better protection than do blankets. Where regular sleeping-bags are not available, substitutes may be extemporized from blankets by the method described in a previous chapter.

The disposal of excreta and refuse is a simple matter in cold climates, since odor and putrefactive processes are promptly destroyed, and when cleansing is necessary the frozen mass is readily removed. Latrines should be sufficiently warm to prevent undue exposure of the person to extremely low temperatures when obeying the calls of nature. In Arctic expeditions, the warm snow-hut or tent, occupied during the previous night for sleeping purposes, is ordinarily used in the morning as a latrine before the abandonment of the camp site on resuming the march.

CHAPTER XIX.

THE HYGIENE OF THE TROOP-SHIP.

THE transport service of the United States army is not the result of long experience and careful forethought, but has been a sudden creation due to immediate necessity. As a consequence, no vessel has been built for the special purpose of transporting troops; but such steam-ships as could be acquired by the Government through emergency purchase, during and subsequent to the war with Spain, were more or less hastily remodeled to suit varying, and supposedly temporary, conditions. The transport *Thomas*, accommodating 1,653 men, may be regarded as a fair type of the larger and better class of troop-ships; but in general these vessels are so dissimilar in tonnage, build and equipment that any attempt at their description as a class is manifestly impossible. Still, there are many general conditions affecting the health of troops on board ship, irrespective of the special structural details of the latter, and these it is the purpose of the present chapter briefly to discuss.

Perhaps the most important sanitary problem on board ship is to get fresh air in, while keeping water out. The simplest devices for the accomplishment of the former end are wind-sails and cowls, in which use is made of the natural movements of air. These, while valuable, give only imperfect results, and hence should be looked upon merely as accessories to more precise means of ventilation. They have the defect of delivering the most air when least needed, require considerable attention, often allow the entrance of water during wet weather, and, by the cold drafts which they may cause, are frequently looked upon as sources of annoyance by those whom they are intended to benefit. For this reason, whenever used, they should be frequently inspected to see that they are in working order and are not plugged or tied up by the men. These forms of apparatus will now be rarely required for the ventilation of troop-quarters except in emergency, and find their chief field of usefulness, on transports, in renewing the air of holds and other dead spaces not used for living purposes. Air-ports assist materially in securing ventilation, but cannot always be kept open on account of rough and stormy weather. They should be provided with pivoted side-lights, by which the air can be forced in or directed outward while the vessel is in motion. They should invariably be kept open except when this is attended with actual risk, and their control, in quarters, should be delegated to non-commissioned officers. Hatch-ways, also, should be kept open during fair weather, but should be screened with gratings for protection against accident. In some ships used for commercial purposes, ventilation is carried on by passing the air from the hold and bilge through the furnace and thus producing an aspiratory effect. In certain British troop-ships, ventilation is secured by an upward draft created

by steam-jets, as already mentioned, but this system is objectionable on account of the noise, the waste of steam and the condensation of water in the air-shaft.

The rotary-fan system is the most efficient and practicable method of accomplishing ventilation on board ship. In this system, the fan revolves in a metal tube, having numerous branches; air being aspirated from the outside and driven through suitable flues to the various parts of the vessel, while a reversal of the fan converts the inlet into a discharge-pipe. With aspiration of the confined air, a fresh supply finds its way into the ship through wind-sails, ventilating-shafts, hatch-ways and ports, entering the apartments by doors, crevices or other natural openings. It is of course necessary that such fans should have fresh-air connections and not merely put in motion air already in the compartment. The system of ventilation used on our transports consists in forcing in fresh air, but this is undoubtedly inferior to a simultaneous use of the supply and exhaust systems. By either method alone, there is a strong tendency to draw in or expel air through the hatch-way or ventilating opening nearest the fans without renewing the atmosphere in the more distant parts of the ship. The fact should not be overlooked, in the ventilation of ships, that the diffusive power of air is small when compared with its tendency to move along the line of least resistance. The amount of air going in and that going out of a space is by no means indicative of the thoroughness of the general circulation.

Each important compartment should have its own ventilating system, for the movement of air is much impeded by bends in the distributing channels. As with barracks, care should be taken that inlet shafts are short and are changed in direction at such an angle as to present the least resistance through friction. The ventilating fans should, of course, be calculated as to number, power and size, according to the amount of fresh air which the maximum number of occupants will require. The outlets and their exhausts should be adapted to the inlets and the supply of air which they admit, and both should be proportioned to the number of persons destroying the air of the apartment to be ventilated. Among other desiderata in all mechanical appliances for this object, they should be automatic, and should also work without noise and without creating perceptible drafts. Their use should necessitate no long shafts or chimneys, which, if carried away by a wave or the wind, would leave openings by which the sea might gain entrance. To avoid drafts, all outlets into quarters should be covered with fine wire-gauze and should present an open space twice the area of the air-shaft.

Effective ventilation demands that every possible obstruction to the circulation and diffusion of air be removed, and hence chests, lockers, racks and other bulky articles should not be allowed in quarters. The thwart-ship bulkheads should be as few as possible, and under all circumstances should be perforated, latticed or louvred at top and bottom. On this account, it would be of advantage if a single compartment, running the whole length of the vessel, could be provided for the quarters of the men. Passages about the ship should be as straight as possible to avoid impeding the movement of air; which must be able to move freely fore and aft and also from side to side, else the ventilation of the lee side of the

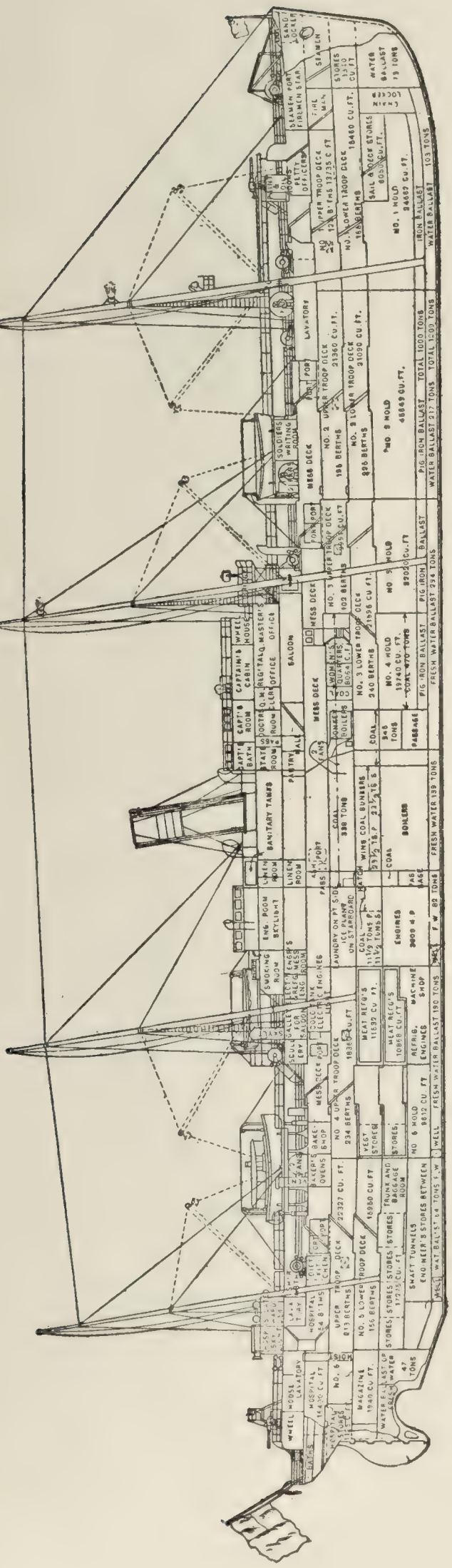


Fig. 1. Mid-Ship Section.

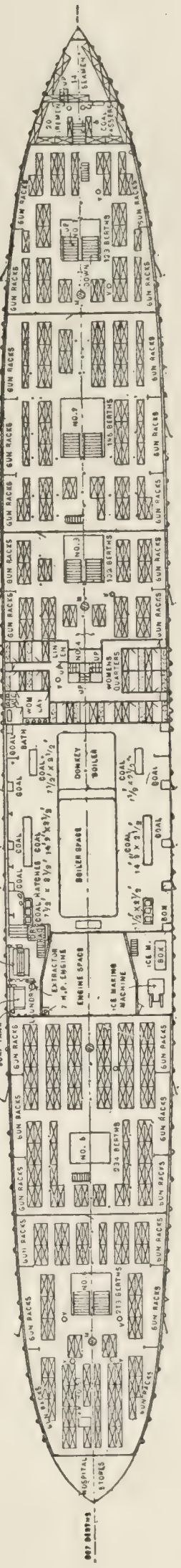


Fig. 2. Tween Deck.

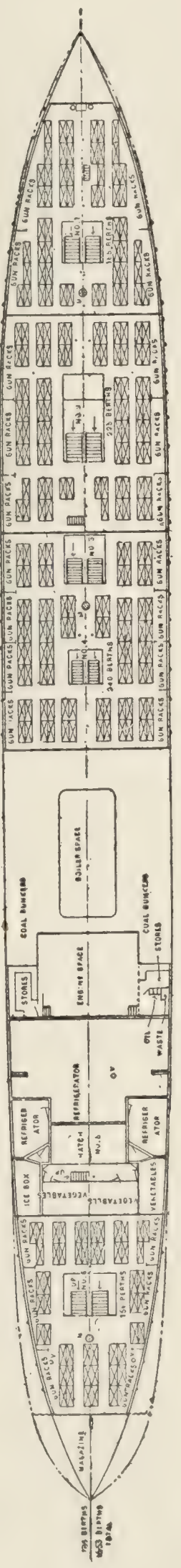


Fig. 3. Orlop Deck.

FIG. 388.—United States Army Transport "Thomas."

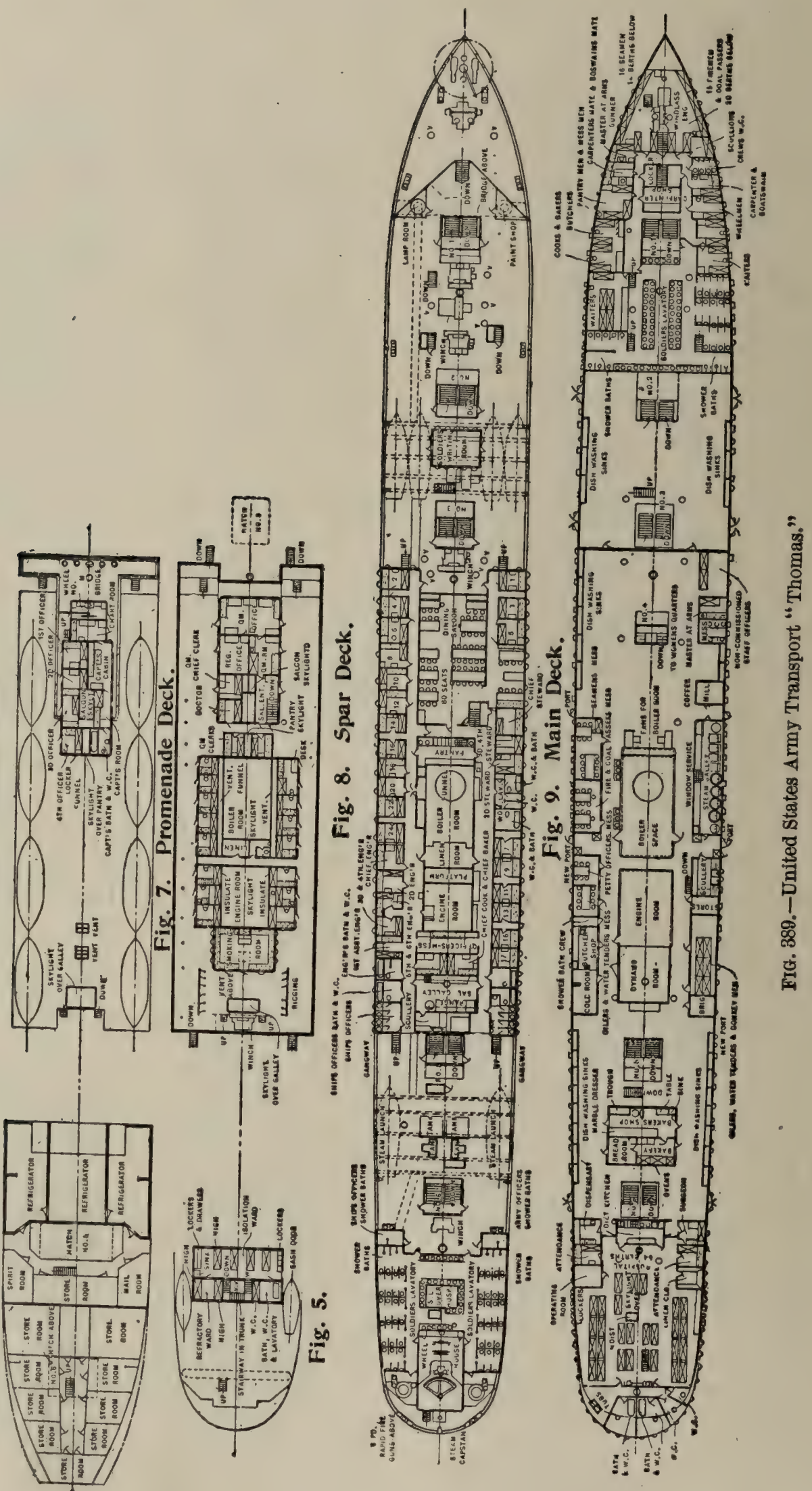


Fig. 4. Lower Deck (aft).

Fig. 5.

Fig. 6. Upper Deck.

Fig. 7. Promenade Deck.

Fig. 8. Spar Deck.

Fig. 9. Main Deck.

FIG. 389.—United States Army Transport "Thomas."

vessel will suffer. Stores, baggage and articles composing the cargo, should be so disposed as to leave passage-ways around and between them. Pantries and store-rooms are too often located without regard to convenience, ventilation, cleanliness and light. Such rooms, together with the galleys, are almost always a source of disagreeable odors and should be specially ventilated by the exhaust system.

To allow proper cubic space to each soldier is usually impossible on board ship. In the merchant marine, the average air-space available per man is rarely more than 125 cubic feet and frequently may be as low as 60; the British maritime laws prescribing 72 cubic feet as a minimum. Every effort should be made, however, to allow at least 200 cubic feet per capita. With this space, supplemented by efficient ventilation and careful police, it is probable that no serious trouble may be apprehended as a result of over-crowding during an ordinary voyage.

When a troop-ship is at anchor, especially in hot climates, a spring should be put on the cable so that the broad side of the vessel, with its numerous portholes and other apertures, may be turned to the wind and thus permit of ventilation by perflation. In the British service, on some stations, this procedure is officially prescribed for ships of war. The anchorage in malarial ports, or those in which disease is epidemic, should be made to windward and at least one mile distant from possible sources of infection. The vicinity of marshes, sewers, festering mud-flats and the mouths of foul tidal rivers, discharging the débris resulting from human occupation along their banks, should be avoided.

The problem of heating, so difficult of solution on sailing vessels, is readily settled on steam-ships by the use of steam-coils. The system should be so planned that a certain portion can be shut off without interfering with another part or with the whole. To reduce the heating of the ship by the solar rays while in tropical waters, the coloring of the external surface should be white or light yellow. Lighting is, of course, best accomplished by the use of incandescent electric bulbs, these giving ample light without danger of conflagration, the production of any great amount of heat or vitiation of an already confined atmosphere.

The universal experience of medical officers is that a damp ship is an unhealthy ship. Dryness is essential—Tryon stating that of two ships cruising together, the sick-rate of the one with the most water between decks is invariably the higher. Nothing is more undesirable than too frequent and indiscreet use of water on the decks, especially those upon which troops must sleep; yet this is the usual routine practice resulting from mistaken ideas of cleanliness. Sea-air normally contains a large proportion of moisture which on board ship is unavoidably increased by bodily exhalations—hence any further and unnecessary increase of humidity by artificial means should be avoided. All decks should be coated with shellac or with linoleum, cemented in place to prevent absorption of moisture. The lower decks should never be wetted except for a brief cleaning, and then only on very dry days and not oftener than once a week. Even open-air decks should be washed only on sunny days and never except when really necessary. The minimum amount of water should always be used for this purpose; its lavish use in cleaning decks generally implying an inefficient police. Where unclean work must be

performed, a subsequent washing may usually be rendered unnecessary by sanding the decks or by the use of tarpaulins. In the British transport service, it is recommended that the decks be sprinkled with clean sand and sawdust when troops put to sea, to receive the discharges from sea-sickness. This is removed on the following day and more laid down; the process being repeated until the men have become habituated to the motion of the ship. The troop-decks can be readily kept clean subsequently by sprinkling with hot sand, holystoning and dry rubbing. It is officially prescribed that wet swabbing should be employed only when required by local patches of filth. All movable articles which require washing should be wetted and dried only in the open air.

The change from wood to iron, in the construction of ships, has increased the disadvantages due to the condensation of atmospheric moisture, with resulting dampness. This fault may be overcome in part by lining the ship with wood; but this material soon becomes dirty and ill-smelling and harbors vermin. Cork-paint, an excellent non-conductor, is now much used as a coating for all metal work, and greatly diminishes condensation. Not only the walls but the ceilings should be overlaid with this material. It should be put on firm, smooth sheets; since when rough it is a constant source of minor injuries through the roll of the ship, and is also retentive of dust.

Particularly is it of importance that the hold be kept dry. One great cause of dampness on board ship consists in taking on supplies in wet weather, and, unless absolutely imperative, the coal and cargo should be loaded only on fair days. Before being placed in the hold, all barrels apt to leak should be whitewashed, as a ready means of discovering leakage should it subsequently occur. An efficient system of ventilation is of great value in drying the ship and diminishing humidity. All drainage naturally tends through gravitation to the bilge or lowest part of the ship, where it forms the highly offensive liquid known as bilge-water. This fluid is a mixture of sea-water which finds entrance through defects in the hull or is deliberately admitted for purposes of cleanliness, of coal-dust and ashes, of oil from the machinery, of fresh water spilled from the tanks and of oozings from barrels of wet provisions. Dissolved in this liquid is a considerable amount of organic débris, which, on decomposing, emits foul odors. The exhalations from the bilge are thus much more offensive and dangerous than the ground-air of a house—to which it is compared by Blyth. It is, in fact, more like sewer-air. The perpetual motion of the ship, although of assistance for purposes of ventilation, only tends to increase the evolution of gases from below by the constant agitation of the bilge-water. To avoid this production of gases, the bilge-space should drain into depressions which can be readily evacuated by pumping. Macdonald recommends that the bilge-floors on either side of the keelson should be made perfectly smooth, and be cemented, lacquered or tiled, with sufficient incline from both ends of the vessel to the well. The liquid which gravitates to these points should be frequently removed and replaced by fresh sea-water. After the lapse of about an hour, this in turn should be discharged, and the proceeding repeated until the fluid brought up is entirely free from odor. On concluding the operation, the bilge should be pumped entirely dry. Great care in keeping the ship dry and clean will

minimize the production and offensiveness of bilge-water. The use of antiseptics and deodorants, notwithstanding their efficacy in preventing foul smells and the evolution of noxious gases, should never be relied on to the exclusion of the frequent and complete removal overboard of the bilge-water itself.

The best location of quarters for troops is where the motion is least, which is abaft the midship section of the vessel; and there should never be more than two decks, preferably only one, occupied by the berths of soldiers. As to floor-space, twenty square feet per capita should be allowed as a minimum, and not more than two tiers of hammocks or bunks should be permitted. Where bunks are used, the lower tier should be raised not less than eighteen inches above the deck; with not less than three feet between the two tiers, and between the upper tier and the ceiling, so as to enable the occupants to sit upright. All bunks should be arranged so as to leavea passage-way at least thirty inches wide between each other and the side of the ship, to facilitate cleansing, allow ready communication and ventilation and prevent chilling from condensed moisture or cold. The bunks themselves should have a frame-work of light iron tubing, painted white or light gray, which should be readily removable and supported on stout iron stanchions. In dimensions, the bunks should not be less than six feet three inches by two feet. Woven-wire mattresses are liable to rust, and are unfitted for use on upper bunks since they allow dirt and dust to fall through on to the bunk below. Canvas strips, stretched between the bed-frames, are cleanly, comfortable, occupy little space and are readily removed and handled. These should be washed after every trip—and more frequently if necessary. Shuck or straw mattresses are totally unsuited for use on board transports and soon become soiled and offensive. Vermin, if found to be present, should be relentlessly pursued. A high standard of cleanliness should be enforced, since on steam-vessels the facilities available for maintaining cleanliness are exceptionally great and no reasonable excuse can be offered for an inefficient police. All bunks should be made up neatly at reveille, rolling back the upper blanket to expose the interior, after which the troops should be sent on deck. The men should not be allowed to sleep on deck after sunset, from the danger of chilling.

On board ship, on account of the necessarily confined quarters, personal cleanliness is of the utmost importance, and the men should be required to bathe the entire person daily. For this purpose the shower-bath, as now provided on most transports, is unequalled. In its absence, a place on the spar-deck should be set aside, where the men can strip behind canvas screens and be doused with salt water from the deck-hose. Swimming, when practicable, is to be encouraged under proper precautions. Special soap, suited for use with salt water, should be issued gratis to troops on embarkation. Abundant lavatory facilities should be provided.

All clothing should be kept clean and dry. For this purpose, each troop-ship should be provided with a steam-laundry and drying-room of sufficient size. Where such facilities are not furnished, two days a week should be set aside in which the men should be required to wash their own clothing by such less convenient means as may be available. When the weather permits, blankets should be exposed to the sun and air at least once weekly. On the conclusion of each trip, all bedding—as mattresses, pillows

and blankets—should be taken on deck and sunned for at least an entire day. The clothing worn by the men should be sufficient and adapted to the climate. The woolen shirt should never be discarded even in tropical seas, for ships are drafty and currents of air are always chilling. All spare clothing and accoutrements should be kept in places assigned to them, and not be allowed to encumber the bunks or occupy space in a sleeping-compartment.

In our naval service, the official allowance of fresh water is one gallon daily per capita. In the merchant marine, the law provides that each passenger and sailor is to be supplied with three quarts of water daily. In the British transport service, the minimum daily allowance of water is six pints out of the tropics and one gallon in the tropics. On troop-ships, however, the amount of water allowed for all cooking and drinking purposes should scarcely be limited; and this can readily be accomplished by means of the distilling apparatus with which they are nearly all provided. The distilling apparatus of the transport *Thomas* is capable of providing fifteen thousand gallons of fresh water in each twenty-four hours. For distilling purposes, only clean sea-water should be employed. Under no circumstances should the water of a filthy harbor be taken on board with a view to its distillation for drinking purposes. Should it be necessary to embark troops on vessels not equipped with means of providing an abundance of fresh water from time to time as required, the quantity stored in the tanks should be sufficient to afford at least one and one-half gallons to each man and eight gallons to each horse as a daily allowance throughout the voyage.

Water is usually stored in tanks having an individual capacity of five hundred or more gallons. Those on the *Thomas* have a total capacity of two hundred and thirty-five thousand gallons. Where the supply is distilled while *en route*, these tanks should be relatively small and more numerous, to prevent the possibility of contamination of a large amount of water through temporary fault in the condensing apparatus. Wooden tanks should never be employed except in case of emergency, since the alternate wetting and drying of the wood, with deficient ventilation, is apt to render the contained water unfit for consumption. Iron tanks, painted without and cemented within, are economical and sanitary receptacles. It would be of advantage if they could be lined, as are bath-tubs and water-closet fixtures, with the so-called porcelain. All tanks should be furnished with large man-holes for securing cleanliness, and thorough scrubbing and rinsing, after emptying, should be carried out as a matter of routine after each voyage. If possible, the man-hole should be so placed that natural light finds its way to every part of the tank when the cover is removed. Where water is distilled, the operation should be done at sufficiently long intervals to ensure palatability and aëration. The latter is usually left to be accomplished by the rolling of the ship; but it may be readily brought about by the use of charcoal filters, by letting the water fall from a height in a state of fine subdivision, or by allowing it to trickle over well-washed pebbles, exposed to a current of air. The fluid in the tanks from which the supply for drinking purposes is immediately drawn should be cooled by pipes passing from the cold-storage room on the way to the ice-machine. It is scarcely necessary to say that suspected water should not be used; or if this be unavoidable that it should be boiled before issue to the men.

With the general adoption of artificial refrigeration, the question of food on board ship, formerly a most serious problem, is now satisfactorily solved. With an abundant supply of fresh meat and vegetables, scurvy is no longer to be feared. The diet should be in no wise different from the ration of the soldier performing light duty in garrison, unless it be made slightly more laxative by the addition of more vegetables to overcome the natural tendency to constipation due to deficient exercise. At the outset of the voyage, to limit the amount of sea-sickness, the issue of fats should be discouraged. Where mess-rooms are not provided, all food should be eaten on deck when the weather permits, and under no circumstances should remnants of food or soiled eating utensils be allowed to remain in a compartment used as quarters. It is well to require all portions of the ship to be swept after each meal, and thus at once remove the crumbs and other refuse food which is often unavoidably scattered on the decks and flooring. Before being disembarked, troops should be served with a hot meal, to limit the discomfort which might result from temporary absence of a food supply on shore or lack of preparation for their arrival.

The disposal of excreta is not the serious matter on board transports that it is in military communities on shore, since all waste has only to be discharged overboard as quickly as possible; and abundance of water, for purposes of cleanliness, is always available. Hence latrines need never become offensive, or possible sources of disease, if given a moderate amount of care. The best form of latrine for troop-ships consists of a broad, shallow trough, having a continuous and ample flow of salt water pumped up by the engines. Seats should be provided in the proportion of at least five to each hundred men. They should be made in individual sections, and should be so weighted as to tip up when not in use—thus allowing the trough to be used for the reception of urine or vomitus without the liability of soiling the seats. The latter should be scrubbed daily with soap and water. All latrines should be wholly disconnected from any sleeping compartment or quarters; the flooring should be impermeable, the surface being finished with a good fall outward. All soil-pipes should discharge at a proper distance below the deck and preferably out of sight. As far as possible, latrines should be in the after-part of the vessel, so that the discharges may shoot over or through the counter at the stern and odors may not pass over the ship when heading into the wind. Ventilation of the latrine-space should be thorough, and an exhaust fan will assist greatly in removing all odors. When lying in dock for any length of time, it is advisable, if such plan be possible, to close all latrines and require the men to seek accommodation on shore at convenient points previously designated. When moored in a closed slip, this precaution is of great importance in the prevention of serious nuisance, since under such circumstances the excreta may accumulate in large quantity and float alongside the ship for a considerable period. All rubbish and garbage are disposed of, when at sea, by being thrown overboard. While at dock, all refuse of this character should either be sent on shore for disposal or should be burned in the furnaces.

The hospital of the troop-ship should preferably be located on the upper deck and be well aft. The latter is a point of less motion, is not so liable to be flooded in case of storm and is the quietest part of the ship. For infectious cases, this location furnishes the best facilities for isolation;

while the air from the hospital, rendered dangerous by the emanations from such cases, escapes directly astern without blowing over an inhabited part of the vessel. In the navy, provision is made for a sick rate of five per cent., but for troop-ships this proportion should probably be increased by one-half. As to the amount of floor-space for hospitals, no rule can be given unless that it be to make the superficies as great as possible.

Before accepting for the transport service a ship owned by private parties, it is desirable that information be obtained as to its medical history. Some ships are less healthful than others, which are said by sailors to be in this respect "unlucky." A ship which has recently had cholera, yellow fever, scarlet fever or diphtheria on board should on no account be accepted. It is stated that ordinary steam-ships can be fitted out as transports in about a week for the transportation of infantry and in ten days to two weeks for mounted troops.

In the movement by sea of large organized units, the amount of net tonnage required may be estimated as follows: For very short voyages, if not more than a day's duration, one and one-half tons net per man and two and one-half tons net per horse. For voyages not exceeding a week, two tons net per man and six tons net per horse. For long voyages to any part of the world two and one-half tons net per man and seven tons net per horse. These estimates include space for one month's forage and provisions for voyages under a week, and for three months' provision for voyages longer than a week in duration. Where a large amount of transport vehicles and animals are embarked, an increase of ten per cent. may sometimes be required. To reduce gross tonnage to net tonnage it is customary in the British service to multiply the former by the factor .65 in the case of merchant steamers, and .6 for ordinary troop-ships. The number of officers a ship can carry generally corresponds with the number of first-class passengers for which accommodations are provided.

Troops under orders of embarkation should be inspected by a medical officer to determine the fitness of each man for service. This examination should be made in sufficient time so that the places of such as are incapacitated for service may be filled by others. In this connection, Wolseley has well written: "To send a weakly man on active service is cruel to the individual, retards operations, renders them difficult, requires larger hospital and medical establishments, and the result is, if not actual failure, at least decreased efficiency and greatly increased cost." No cases of contagious or infectious disease should be received on board, with the exception of mild cases of venereal infection. Pregnant women within three months of confinement should not be given passage on a transport.

On the embarkation of troops, the routine issue of a laxative, preferably in the form of a mercurial, will be of advantage in the prevention of seasickness. Large doses of the bromides of sodium or potassium may be administered for the same purpose; but these should naturally be given only in individual and selected cases. The diet immediately previous to departure, and during the first few days of the voyage, should be light, digestible and not of a greasy nature. Before sailing, three or four men should be detailed from each company—such as are understood not to be subject to seasickness being selected—and these should be kept alternately on duty as a sanitary police, day and night, until convalescence from this affection has

been generally established. The sea-sick who vomit or discharge urine or excreta on their bunks or in quarters should be removed to the fresh air, and all discharges and filth at once cleared away. Such cases should be compelled to remain on deck, being allowed their mattresses and blankets if too ill to sit up. Compulsory exercise between two men, and compulsory feeding with hot soup or coffee, will often aid recovery in more protracted cases. The use of bilge-keels does much to diminish rolling and the consequent liability to sea-sickness as a result of such motion.

Weather permitting, the men should be required to remain on deck throughout the day; and for their better protection, in hot or rainy weather, awnings should be spread fore and aft. Seats should be provided, and lying down on wet decks prohibited. Several hours' exercise daily, in the form of drills, setting-up exercise and marching around the decks, should be required—and to assist in preventing *ennui* and vary the exercise, a small detail may perhaps be made daily to assist in working or cleaning the ship outside the quarters of the men themselves. The transport should be speedy, to bring the journey to a close as soon as possible—for discontent and nostalgia operate, during long voyages, to a greater degree upon the soldier than the sailor. As in camp, music and diversion of all kinds are of the greatest value. Target-practice at floating bottles or a mark towed behind the ship is a pastime at once interesting and valuable from a military standpoint.

The conditions prevailing on board transports must be considered, at best, as being somewhat unfavorable to health. Fortunately, the time consumed by troops in changing station by sea can rarely be great under modern conditions, and the period through which such injurious influences act is usually brought to a close before the effects of the latter are markedly apparent.

CHAPTER XX.

THE DISPOSAL OF THE DEAD.

PROPER disposition of the bodies of dead is demanded as well by sentiment as by the interests of public health. In the military establishment, the disposal of the dead without prejudice to the interests of the living may become a sanitary problem of the greatest importance; requiring, under certain circumstances, the adoption of unusual measures to ensure its proper solution.

From the standpoint of the sanitarian, the ideal method of disposition is through modern processes of cremation, as exemplified by the Siemen's crematory, since the destruction of dead bodies, rapidly, completely and inoffensively, is insured by this method. Unfortunately, however, cremation is so rarely performed among civilized and Christian nations that, as a means for the disposal of the dead in the military service, under ordinary circumstances, it does not at present warrant serious consideration.

Interment.—The location of burial-grounds should be determined only after most careful sanitary investigation and full determination of the present and probable requirements of the military community. The surface-configuration and character of the soil, facilities for drainage, trend of ground-water, proximity to water-courses and distance from habitations are all considerations of importance. A cemetery-site should never be higher than the foundations of neighboring habitations, but should be sufficiently elevated to afford good drainage. Low ground, liable to be flooded or in which the ground-water is apt to rise, should be avoided; since excess of moisture greatly retards the processes of disintegration. The nature of the soil has a great influence on the decomposition of the dead body, and a clay soil or hard or stony ground is undesirable for this reason. Saponification of the cadaver, in the production of adipocere, is liable to occur after burial in moist clay as a result of a deficient supply of oxygen. Loose, loamy soil should preferably be selected, since the free movement of ground-air and ground-water is thus permitted, both being essential factors in the promotion of rapid dissolution. A site requiring subsoil drainage can scarcely be considered as fit for use for general burial purposes. The trend of the ground-water should not be from the cemetery toward any wells which are sources of water-supply, nor should the drainage be such that the contamination of such surface-waters as are used for domestic purposes becomes possible. The site should not be too heavily wooded, but, on the contrary, it should not be devoid of large growth. A strong covering of turf with a sparse growth of trees and shrubbery will, through their roots, have an excellent effect in the absorption and utilization of the products of decomposition. Under ordinary conditions, a vacant space of five hundred feet between a large cemetery and surrounding habitations is not an excessive requirement.

The rapidity of dissolution of dead bodies depends largely upon the chemical or other methods taken for their preservation, the nature of the soil, the presence of ground-air and the condition of the ground-water. The use of strong outer casings or of metallic caskets, together with the embalming of the remains, is objectionable from a sanitary standpoint—as retarding decomposition and thus, without proper reason or justification, preventing an early return to the elements. In temperate climates, under favorable conditions, the process may ordinarily be completed in three or four years; but, on the other hand, even without chemical preservation and the use of metallic caskets, the disintegration of bodies under unfavorable conditions may be very slow—thirty or forty years being consumed in the process. Deep burial should always be required, and bodies should not be interred at a less distance than five feet from each other. Single graves should always have a depth of five or more feet in order properly to retain the odors of decomposition, and at least four feet of earth should always cover their contents.

Bodies of those who have died from contagious disease should not receive a public funeral, and are to be buried or otherwise disposed of as soon as possible after the fact of death is established. In all instances, interment should occur with the least possible delay; since action to the contrary cannot but be detrimental to the general health. In this connection, it should be noted that ceremonials expressive of honor and respect, bestowed upon the soldier dead, exert a powerful influence in raising the morale of the military community.

Embalming.—The procedure of embalming is objectionable from a sanitary standpoint, in that it exerts a very great effect in preventing decomposition of the dead body and its speedy resolution into innocuous elementary compounds. Through sentimental and æsthetic reasons, however, this process has become so popularized as to be desired by friends or relatives in nearly every instance where death has occurred. During the Civil War, the troops in the field were for a time accompanied by a horde of professional embalmers, who advertised their trade in the purlieus of every camp—with an unfortunate effect upon recruits—until finally their presence was forbidden by military orders. Embalming, at the present time, has received a quasi-recognition in the military service of the United States through recent action attaching a civilian embalmer to each army transport to prevent the necessity for burial at sea.

To the medical officer, often dependent upon his own resources in an isolated station, the subject of embalming, aside from its sanitary aspect, is possessed of practical interest; inasmuch as in the absence of those upon whom such duty properly devolves, he may be requested to prepare the dead for transportation to some distant point for burial. While engaged in active hostilities, it is evident that this process can rarely be carried out; but even at such a time the preservation of the remains of some officer of high rank and public character may of necessity become the care of the medical department.

The solutions used by embalmers are largely secret proprietary preparations, most of which contain about 10 per cent. of commercial formalin, 5 per cent. of chloride of zinc, and arsenite of soda and alum in saturated solution. A 1–500 solution of mercuric chloride, with chloride

of zinc in 5 per cent. strength, is said to give good results in preserving and blanching the tissues. By the use of too strong a solution of formalin, the body is stiffened so rapidly as seriously to interfere with the work of the embalmer. Non-poisonous substances, such as salicylic and boric acids, have been tried, but these have not given satisfactory results. In general, the best time for the operation of embalming is about four hours after death; but it may satisfactorily be performed at any time prior to the establishment of putrefaction. When the blood is disorganized, as in sunstroke or septic poisoning, it should be performed as soon as the fact of death is well established. The instruments required are a stout scalpel, a set of large aspirating trocars, a set of short hollow needles for arterial injection and a strong double-action aspirating pump. For the injection, an artery is bared, either the femoral or brachial, a hollow needle is inserted, pointing toward the heart, and the embalming fluid is slowly passed in, stopping when a sense of resistance is felt or if the face shows signs of becoming œdematous. About fifteen minutes is usually required for this process, and about three quarts of fluid, in the case of an adult, are used. Following the injection, a long trocar is plunged obliquely upward through the abdominal wall, at a point two inches above and to the left of the navel, piercing the pericardial sac and entering the cavities of the heart. The aspirating pump is then connected with the trocar and the blood slowly drawn off; usually amounting to about two quarts and requiring slow aspiration during about ten minutes. This operation is continued until the appearance of clearer fluid shows that the greater portion of the blood has been removed. The trocar is then partially withdrawn and directed downward, perforating the intestines and permitting the escape of any gas or dropsical fluid. The bladder is also punctured and the urine withdrawn through the trocar, about two quarts of embalming fluid being returned through the instrument into the abdominal cavity. The rectum is well packed with pledgets of wet absorbent cotton, and, in cases of somewhat advanced putrefaction, a rubber catheter is passed through the nose and a pint or more of embalming solution allowed to gravitate into the œsophagus and stomach.

In case a post-mortem section of the body has been performed, injections of embalming fluid are made in both carotid arteries, in the direction away from the heart. The viscera are removed, the abdominal cavity is packed with absorbent cotton soaked in embalming fluid, the cut in the abdominal wall stitched up and a considerable quantity of the preservative thrown into the œsophagus.

To preserve a natural appearance to the face for a considerable length of time, small papier-maché, card-board or tin disks are inserted under the eyelids, several layers of cloth, wet in equal parts of alcohol and glycerin, are placed over the face and neck and the whole is wrapped in oiled silk. Ecchymoses may be removed by sponging with warm water, accompanied by gentle massage of the discolored parts.

Transportation of the Dead.—The transportation of bodies of persons dead of smallpox, Asiatic cholera, yellow fever, typhus fever or bubonic plague should, under all conditions, be absolutely prohibited.

The remains of such individuals as have died from diphtheria, scarlet fever, glanders, anthrax, erysipelas, typhoid fever or other dangerous communicable disease, should not be permitted to undergo transportation unless

disinfected by arterial and cavity injection with some strongly germicidal embalming fluid, followed by thorough washing of the entire body with a solution of mercuric chloride, 1–1,000 strength. After being thus disinfected, the body should be enveloped in a layer of raw cotton not less than one inch thick, be completely wrapped in a sterilized sheet and the whole snugly bandaged in place. Shipment of a cadaver so prepared should be carried out in an air-tight metallic casket, all joints and seams of which have been hermetically sealed. The caskets now in use for this purpose, in the army of the United States, are constructed of copper and have a removable front held in place by numerous stout thumb-screws. At this single joint there are, on both the shell and front, thick rims of soft rubber coming together in the form of a tongue and groove; this arrangement, when compressed by the action of the thumb-screws, renders the casket air-tight. As an additional precaution, it is customary to coat both rims heavily with white lead prior to the final application of the casket front. This metallic shell is then placed in a coffin, and the whole packed, with the aid of excelsior, in a stout wooden box. This outer box is constructed of one and one-half inch clear pine lumber and is reinforced by two strong five-inch pleats on top and bottom; the ends of the box, for further security, being bound with hoop-iron.

Every disinterred body, dead from whatever cause, should be treated as infectious and hence as dangerous to the public health. Bodies deposited in receiving vaults should be considered as the same as those which have been buried and the precautions outlined above should be in all cases required.

The remains of such persons as have died from causes not contagious, infectious or communicable in character, may be safely transported without special preparation, in a temperate climate, if encased in a sound coffin or casket and enclosed in a strong outside wooden box; provided they can reach their destination within thirty-six hours after the time of death. If the arrival of such a body at its destination within this period cannot be assured, it should be treated as if infectious in character and prepared in the way already described.

Sanitation of the Field of Battle.—The responsibility for the sanitation of the field of battle devolves upon the conqueror, even if the victory be promptly followed by pursuit. This sanitary work should be under military control, but may often be largely performed by the inhabitants of the surrounding country, impressed for this service, who naturally are most directly interested in the result to be obtained. They should be assisted by such prisoners of war and soldiers on fatigue duty as may be available. If necessary, special organizations should be detailed to assist in the proper accomplishment of the task.

Inhumation.—The sepulture of those killed in action must of necessity be accomplished on the field of battle, and only in rare instances or after slight engagements can bodies receive special care or be given shipment to the rear for interment. Prompt inhumation of the slain, both men and animals, is necessary if the scene of conflict is not to become a possible starting-point for pestilence—the rapidity of the action required depending largely upon the season and climate. Burial after battle is often improperly carried out on account of the lack of time available and the desire to secure the disposal of the greatest number of cadavers in the least period; hence

the history of warfare, and particularly of sieges, is full of instances where the occurrence of epidemics has apparently been largely favored by the insufficient attention given to the disposal of the dead. Much of the sickness in the French camp during the Crimean War was attributed to this cause, Truser stating that the "corpses of our friends have become greater enemies than the Russians; barely covered with earth they emit a pestilential miasm which kills better than powder and shot." The thirty thousand corpses hastily interred near Metz were undoubtedly a strong factor in the production of disease among the German troops, forced to remain in the vicinity, and it was observed in both the instances above noted that the organizations encamped nearest the field of battle were the ones most ravaged by sickness.

It is impossible to carry out separate burial after an action resulting in any great number of fatalities, but where the dead are few in number they should preferably be buried in individual graves. Officers can generally be interred separately. It frequently happens that, at the request of families or friends of the deceased, permission for the exhumation and removal of the remains is subsequently granted, provided such action be compatible with public safety.

In campaign, after a battle, it is rarely possible to transport the dead to any great distance, and hence they are usually interred near where they have fallen. Should an entrenched force be driven from their line of resistance, the captured trenches will often prove available for this purpose; but if these trenches are to be re-occupied, the dead should not be buried in their vicinity nor in the neighborhood of a camp, hospital or collection of human habitations. The rules governing the selection of a cemetery site are also operative in the location of the graves of the dead after battle.

Where a large number of cadavers are to be buried in a single trench, the latter should have a width of seven feet, a depth of ten feet and a length proportionate to the number to receive interment. Branches of trees may be thrown into the bottom of the trench to facilitate drainage. The dead should be completely stripped of their clothing prior to being placed in the grave, since the parts covered by garments resist putrefactive processes to a much greater degree. The bodies are placed in layers, in the recumbent position, but should not approach nearer than three feet to the surface of the ground. After filling in the grave, the excess of earth should be piled over its site better to retain the odors of decomposition, mark its location and protect against animals. The mound should, if possible, be sodded, and such vegetation as possesses great power for using nitrogen and has long roots, as clover, should be sowed or planted.

Where single bodies have lain undiscovered after an action until putrefaction was far advanced, it is sometimes preferable not to attempt to move the body for burial but to heap a large amount of fresh earth over the corpse itself.

When properly inhumed, the decomposition of the dead progresses rapidly, and the products of putrefaction are eagerly seized upon and utilized by vegetable life. Should hastily buried cadavers become offensive, the superimposed earth may be removed and the bodies burned by the method subsequently described; or they may remain undisturbed and a large amount of fresh earth heaped over the burial place.

Interment in quicklime hastens destruction, but sufficient quantities of lime for this purpose are rarely attainable on the field of battle. During the siege of Paris it was directed that the dead within the walls should be buried in this manner, and during the Prussian occupation of Chalons numbers of the victims of infectious disease were covered with this substance upon burial. Where bodies are interred in a general grave, the several layers should, if possible, be separated by four or five inches of quicklime. Powdered charcoal may also be used to retain odors.

To prevent the possibility of mistakes, it is desirable that a medical officer should be present with the burial-party in order to make certain of the death of the individuals to be interred. Before burial, the identity of the soldier, should, if possible, be established, and, wherever practicable, the interment of the individual should be accompanied by the burial on the person of some token by which recognition can be made in case subsequent exhumation is desired. An excellent method for the attainment of this object consists in sealing up a paper, containing the necessary data, in a clean glass bottle and interring the same with the body to which it refers. The clothing of the dead, after examination to determine the identity of the wearer and to secure any valuables for return to the family or friends, should be destroyed by fire.

The same principles apply to the disposition of dead animals as do with regard to human dead, except that the burial-trenches are necessarily made larger and deeper, and that, with an abundance of fuel, their cremation is preferable. As already noted, certain portions of the flesh of recently killed horses or mules may often be excellently utilized for food prior to their burial or destruction by fire.

Cremation.—In the military service, destruction by fire has often been employed after battle or during sieges when interment of the dead was impossible. During the siege of Troy, the partial cremation of the slain Achæans was advocated by Nestor, so that their bones might be returned to their native country and there given sepulture. Among the Athenians the bodies of such soldiers as fell in battle were collected in tents, to ensure their recognition, and after several days each family or clan conveyed its dead, in cypress coffins, to the ceramicos or place of common burning. Numerous dead Moors were burned by Ferdinand the Catholic; while during the wars between the English and French—the latter led by Joan d'Arc—the dead were on one occasion heaped up outside the city of Paris and consumed on a single huge funeral pyre. After the capture of Taragonne by the French, in 1811, 4,000 cadavers were burned in the public squares of the town. For this purpose, according to Dufour, pyres were erected, composed at the base of beams, planks and large timbers, upon which was placed a large amount of dry brush, fagots and kindling-wood. Upon this foundation was disposed a layer of bodies, care being taken that they did not exactly touch, a second layer of brush was superimposed and an additional layer each of bodies and brush completed the preparations. Such a pyre is said to have cremated three hundred to four hundred bodies without difficulty. In 1812, during the retreat of Napoleon's army from Moscow, the Russians habitually destroyed by fire the bodies of the French dead, as well as those of the animals which had perished along the roadside. In 1814, after the battle of Paris, the Ger-

mans are said by Viry to have burned some four thousand dead bodies during a period of two weeks; the method employed being to place them over a hot fire upon an iron frame supported by stone pillars. In 1815, at Waterloo, several thousand of the slain were cremated on piles of resinous wood.

During our own Civil War, it was not found necessary to resort to cremation of the dead; but on several occasions during the Franco-Prussian War the operation was successfully accomplished on a vast scale. At Sedan, the improperly buried dead were bared of earth, the upper layer of bodies was covered with coal-tar, straw and brush-wood, and the whole ignited. So great was the heat produced and so rapid was the combustion, that, according to Guillery, in less than an hour the contents of the burial-trenches had shrunk to one-fourth in bulk. For the incineration of each two hundred and fifty to three hundred bodies, only five or six barrels of tar were required. The residue consisted merely of calcined bones, and the earth in the vicinity of the burial trenches was thoroughly dried and disinfected. The operation was completed by covering the residuum with quicklime. During the Turco-Servian War, the Servians frequently cremated the fallen; while the English, in India, have often disposed of the dead by funeral pyres. During the French campaign in Dahomey, in 1892, General Dodds is said to have made a practice of destroying by fire the remains of all those killed in battle; and cremation of the dead, with full military honors, was practiced by the Japanese with excellent results in the Chino-Japanese War in 1897. In 1898, after the capture of Santiago from the Spaniards, a large number of bodies found unburied on the occupancy of the city were disposed of by fire. The pyre was constructed of large timbers intermixed with small pieces of wood and hay. The bodies were placed on the pyre and thickly covered with hay and brush; the whole being saturated with petroleum before ignition. Eighty-seven bodies were burned in one pyre, and the results were in every way satisfactory. In the subsequent sanitary regeneration of the city, all dead animals were burned with the combustible rubbish after the mass had been saturated with petroleum.

The destruction by fire of large numbers of the dead, as was carried out by the ancients, is extremely difficult of proper execution, and incomplete cremation must exert an unfortunate effect upon such persons as witness the operation. If the cremation be improperly or incompletely performed, there is no doubt but that the spectacles presented may be of a ghastly nature and repugnant to modern ideas; but these objections cannot apply if the operation is properly executed. The carcasses of horses and mules, often killed in large numbers, should be collected and burned after a battle —their destruction by fire often being a serious sanitary problem from the amount of fuel required.

For purposes of cremation, the use of coal-tar is excellent, since it is well understood that the combustion of resinous and empyreumatic substances, combined with animal fats, produce a heat of great intensity. Crude petroleum, rosin, turpentine or similar inflammable substance should be freely employed in connection with the use of coal-tar. The pyres should have a solid foundation of large timbers, upon which is placed a large amount of small pieces of dry wood or fagots. The operation of cre-

mation, under such circumstances, will naturally be accompanied by the production of a thick, sooty smoke having a strong, unpleasant odor.

According to Laveran, the general rules to govern the sanitation of the battlefield are: Careful burial of human bodies. Burning of horses and débris by the use of coal-tar. Cremation by the use of coal-tar of such dead as were improperly buried. In forts or besieged towns to use the existing crematories for the destruction of the dead, or to practice burial in quicklime.

Public sentiment is strongly in favor of burial as a means of disposition for the bodies of those killed in battle, although destruction by fire is fully as honorable a method for their disposal. Cremation of the dead, however, will be required for the protection of the interests of the living in all instances where proper interment cannot, for any reason, be accomplished.

Portable Crematories.—The portable crematory car invented by Kuborn and Jacques is fitted with removable flanges on the wheels so that it can be readily drawn by rail as well as hauled over ordinary roads. It consists of a large iron chamber with a double floor sloping toward the center, upon which the bodies to be cremated are placed—each floor accommodating three cadavers. Under the floors are located two furnaces, a series of dampers on the sides admitting the necessary air for combustion. The floors are heated by the furnaces, the grease and oils running down into the central pipe and then into one fire, where they are consumed, while the gases disengaged in the process of cremation and the fumes from the first fire are deodorized by being passed through the second fire and are ultimately discharged through the chimney of the apparatus. Only six bodies can be burned in this crematory every one and one-half hours, and hence the number necessary to meet the needs of a bloody conflict would be very great. After the battle of Metz, according to Viry, the services of no less than one hundred and fifty such crematory wagons would have been required. With regard to the employment of such apparatus during campaign, it is evident that limited capacity renders their use impracticable even if it were desirable; further, their very presence would have a dispiriting effect upon young and newly raised troops. The only use of such portable crematories, if any, would be in connection with a besieging army or during epidemics.

CHAPTER XXI.

SANITARY INSPECTIONS IN THE MILITARY ESTABLISHMENT.

It is through the reports of sanitary inspectors that superior authority habitually learns of the existence of evils previously unknown but requiring remedy, as well as the truth concerning unsanitary conditions reported through other channels, and is thus able promptly to correct or minimize the faults for the continuance of which it would otherwise have been held responsible.

The Medical Department, under the direction of the Secretary of War, is charged with the duty of investigating the sanitary conditions of the army and making recommendations in reference thereto. It is prescribed in army regulations that: "The surgeon, under the direction of the commanding officer, will supervise the hygiene of the post or command and recommend such measures as he may consider necessary to prevent or diminish disease. He will examine at least once a month, and note in the medical history of the post, the sanitary condition of all public buildings, the drainage, the sewerage, amount and quality of the water-supply, the clothing and habits of the men, and character and cooking of the food, and immediately after such examination will report thereon in writing to the commanding officer with such recommendations as he may deem proper. The commanding officer will return the report with his views and action endorsed thereon, and if he deem the action impracticable or undesirable will state fully his objections. The endorsement will be recorded in the medical history of the post, and the report and endorsement will be forwarded by the surgeon, through military channels, to the surgeon-general." Under the authority given by the above regulation, the recommendations of the medical officer acting as sanitary inspector are not, as some commanding officers would have it, merely unwarranted criticism of their administration by military inferiors—and as such to be disregarded or resented. In the work of the medical officer, his duties as sanitary inspector are specifically laid down as being of the first importance and are officially given precedence over such purely professional obligations as the care of the sick and wounded. Hence in the proper performance of this duty, the sanitary officer may be assured of the constant support of higher authority, wholly irrespective of any attitude which may be assumed by the occasional supersensitive individual who sees in every effort to promote the general welfare a reflection upon his own efficiency.

In the United States service, the system of sanitary inspections was instituted in 1862, when a sanitary expert was detailed in each army corps and required to visit and report upon the health and condition of every regimental camp in the command. Extracts from his reports were sent to the officers concerned. The greatest good resulting from these inspections ap-

peared to be the official approval and support by the inspector of the efforts and recommendations of the regimental medical officers. This plan was discontinued after the Civil War, and the medical officers returned to their antebellum status, as defined by regulations. From that time until 1874, no provision was made for sanitary inspections, although the medical officer accompanied the regimental or post commander on his monthly rounds in order to give his professional advice if it were desired. Any initiative on his part was not, however, countenanced. In the year mentioned, however, a general order was published which changed the status of the medical officer from that of the physician to that of sanitary adviser, and gave the final action on his recommendations to higher authority than the post or regimental commander directly concerned.

In some armies, a distinct corps of officers, permanently appointed, perform the special work of sanitary inspection, but in our service it is the practice temporarily to detail those whose special qualifications determine their suitability for such duty. That the former plan conduces to greater efficiency cannot be doubted; on the principle that, in any class of work, the amateur, as a general rule, is necessarily inferior to the professional. It is especially provided in our army that sanitary inspections of large camps "should be made by senior medical officers, brigade surgeons and, in special cases, by chief surgeons." The senior medical officer with a regiment or detached command of course inspects within the limits of his own jurisdiction. The experiment has recently been tried of placing the responsibility for the hygienic condition of a camp upon a regimental sanitary board composed of the senior medical officer and a major of the line —fairly good results having been obtained under this system. Unfortunately, however, the line officer is prone to find his sanitary functions less interesting than purely military duties and this cannot fail largely to impair the value of his services.

The duties of sanitary inspectors require the performance of frequent tours of observation through the command to which they are attached. Usually these are periodical; but special visits, when and where required, are made according to varying needs. In general, complete sanitary inspections of all camps, posts or hospitals should be made weekly to ensure that instructions as to sanitary improvements are carried out—company commanders being required by regulations to make daily inspections of their company quarters and kitchens. The greatest disadvantage in this, an otherwise excellent system, is that policing and inspections are liable soon to become synonymous in the mind of the soldier, to the exclusion of the object for which both functions were instituted. Hence the effort is often made to show clean on the surface irrespective of the condition beneath; the result being scarcely to be considered desirable from the standpoint of hygiene.

Thoroughly efficient sanitary inspections can be made only by those fitted for the work through special knowledge and education or long experience—and, since much of their duties relate to diseases, their causes, modes of propagation and means of suppression, a medical training becomes an essential qualification. For the military service, intelligent sanitary inspection rests upon a knowledge of the following subjects:

1. Thorough familiarity with army regulations and existing orders, with

the conditions normally prevailing in the military service, the special needs of troops, the means available by which desired changes may be brought about and the special characteristics of the soldier—all determined by competent knowledge based on ample personal experience with troops serving under varying conditions.

2. Natural philosophy, embracing the principles of pneumatics, hydraulics and hydrostatics, with especial reference to ventilation, water-supply, drainage, construction of habitations and sanitary engineering in general. The laws of natural philosophy will be of great aid in tracing nuisances, determining the sufficiency of ventilation and in studying atmospheric changes.

3. The principles of chemistry, particularly with regard to the methods of analysis; and microscopy, including the elements of bacteriology. Such knowledge is indispensable in the formation of accurate judgment as to impurities of air and water, injurious impregnation of the soil, adulteration of food, the accurate diagnosis of disease, and the efficient use of disinfectants.

4. The sanitary construction of barracks, quarters and hospitals; including knowledge of soil, structure, material, heating, lighting, ventilation, water-supply, house and soil drainage.

5. The immediate and remote effects of over-crowding, vitiated air, impure water, bad or insufficient food, the character of nuisances injurious to health, the disposal of excreta and refuse, and the effects of soil, season and climate upon the health of localities.

6. Knowledge of the causes, methods of propagation and best methods of prevention of infectious diseases.

7. A sufficient knowledge of the civil laws of the vicinity relating to public health.

In addition to his familiarity with the above subjects, the skilled sanitary officer should be of methodical and industrious habits, competent in observation, impartial in judgment and conscientious in action. He should be fertile in resource and economical of time and labor. Thoroughly cognizant of the responsibilities of his position with reference to the preservation of the health and efficiency of the command, he will be quick to appreciate impending disaster as well as energetic in its avoidance or diminution. Not the least in importance, he should possess that rare tact and uniform courtesy so necessary to prevent opposition to his efforts—with consequent impairment of his usefulness—on the part of those upon whose administration he may be called upon to comment adversely.

The official relations between the inspector and the officers of whose troops he has the sanitary oversight, naturally vary with the authority possessed by the former. In times past, it has been thought best by those in control of the military establishment for the sanitary inspector to exercise no actual authority, making his position purely advisory. This plan may answer sufficiently in garrison under conditions of peace; but in active service in the field, or in time of epidemic, it is imperative that the sanitary inspector be clothed with full executive powers in his own department, to enable him to accomplish the prompt abatement of unsanitary conditions without the routine delay which unavoidably follows the official reference of the matter to higher authority. The discriminating inspector

possessed of such authority will rarely find it necessary to utilize his prerogative in this respect; a simple suggestion, backed by the knowledge on the part of others of his ability to enforce any needed changes, amply sufficing in nearly all cases to accomplish the desired results. Where further action is necessary, the sanitary officer should write the necessary orders in triplicate, by the authority of the commander of whose staff he forms a part; one copy being given to the officer concerned, one being forwarded to the adjutant-general or regimental adjutant interested, and the third being retained for file. In this way, the desired result would be obtained and the sanitary officer would be held responsible for any misuse of authority by the commander in whose name the order was issued. It is understood that a plan somewhat of this character has recently been tried, in connection with the large recruit and volunteer camps in the Department of California, with excellent results, and it is to be hoped that it may be given a wider application in the future. There should certainly be some way by which line officers, temporarily in authority over a camp or post, should not be permitted to ignore, belittle or overrule the sanitary recommendations of medical officers, who are qualified by experience and study to render expert judgment in matters to which line officers have naturally paid little attention, concerning which they are comparatively ill informed and upon which they are, from their technical training, unfitted to express a decisive opinion. It is true that in many cases where the inspector, even if possessing no actual powers, informs local commanders of the existence of an evil and confers with them concerning its abatement, it will usually be found that faults in the power of subordinates to remedy will be cured without recourse to superior authority. The exceptions to this are sufficiently numerous, however, and the results of such sanitary derelictions are so serious—not only to the command directly concerned but to other organizations in the vicinity—that it would seem that, in the field at least, the sanitary officer should have delegated power to direct the carrying out of such emergency measures as appear to be in the interests of the public safety. On the other hand, the preservation of health in the military establishment must not be considered as objective with sanitary officers alone. Too much is expected of them in this respect and too little is done by line officers in co-operation with them; armies, like individuals, must act in concert with their medical advisers if they would maintain their health.

In the absence of any action upon recommendations which have been previously made by him, the sanitary officer should consider it his imperative duty repeatedly to urge, at proper intervals, such sanitary improvements as may be indicated—for the conscientious discharge of his obligation to those whose physical well-being is entrusted to his care, as well as to escape the measure of blame which would otherwise attach to him as a result of an epidemic outbreak of disease depending upon unsanitary conditions. It has been officially decided that repeated recommendations with regard to needed sanitary improvement do not constitute a criticism of the administration of the officer in command, but evince a proper performance of duty on the part of the inspector.

While it is obviously undesirable to enumerate the great number of conditions which should come under the observation of the sanitary in-

spector, a brief summary of the salient points may be of value; bearing in mind that not only such matters as are obviously those of sanitation but also every irregularity or abuse, every violation of law, orders or regulations concerning the general health and welfare of troops should receive his attention. Hence men, manners, mind, diet, dress and discipline all fall legitimately within the province of the sanitary inspector.

With reference to the healthfulness of a site or locality, the following points should receive consideration: Height above sea-level and elevation of hills above the plain. Angle of declivity of hills; relative proportion of hill and plain; number, course and character of valleys and ravines; dip of strata and geological formation; water-sheds, marshes and water-courses; exposure to winds and their prevalence and character; sunlight, its amount and duration; amount of rain and frequency of dust. The relation of the site to adjoining land; the height and fluctuation of the ground-water; the nature and condition of soil, whether wet, dry or made ground. The vegetable and animal products, their nature and amount and their adaptability to furnishing supplies for troops. All defects of position, ditching and drainage; and, with camps, the frequency with which the site has been changed and the probable degree of soil-pollution.

Careful attention should be given to the sufficiency, suitability, condition and cleanliness of all buildings or tentage, and to the clear space existing between them. The buildings in use as barracks, hospitals, guard-houses, married soldiers' and officers' quarters; as regards position, exposure, the materials of which they are built, their structure, means of drainage and ventilation. The material and character of roofing; the number, length, breadth and height of rooms; the number of men they are capable of containing according to accepted sanitary standards and the number actually quartered in them; the floor-space and cubic air-space afforded each man. The number of blind spaces not directly connected with the external air; the number and position of windows, transoms and doors; the sufficiency of window-space and its freedom from obstruction. The dryness or dampness of rooms; the character and sufficiency of ventilation; the size of fresh-air inlets, their cleanliness and freedom from obstruction; as to the opening of these inlets above or below the surface of the ground and their proper protection; the suitability of the points at which fresh air is discharged within the building. The sufficiency as to the number and surface of ventilating outlets; their efficiency, proper repair and intelligent control. The size and depth of the cellar; the character of its walls and flooring and its condition as to dampness. The use to which it is put, the sufficiency and means of its ventilation, and the amount and character of any refuse present. The character of ventilation under the building. The dimensions of outbuildings, the purposes for which they are used and their relation to barracks or quarters. The provision for artificial lighting; its sufficiency and suitability. The methods of heating; as by furnace, stoves, steam or hot air. The presence of coal-gas; the nature and amount of fuel; the provision and ready adjustment of dampers; the existence of suitable air-shafts to furnaces.

In the inspection of plumbing, it should be noted whether this is hidden or exposed and the duration of time in which it has been in position; the character and sufficiency of bath-room and lavatory facilities; the suf-

ficiency, tightness and cleanliness of waste-pipes; the presence of any offensive odors and the condition of woodwork near the fixtures. The number, style, sufficiency and cleanliness of urinals and water-closets; the material, size, trapping, ventilation and angle of connection of soil-pipes. The condition of drains, whether exposed or underground, the material of which made and whether clogged or leaky; the angle of junction with sewers, and whether provided with an intercepting trap to prevent ingress of sewer air. The material of which sinks are made, their suitable trapping and their use only for proper purposes. Cesspools, whether tight or leaky, full or clean, tightly covered or well ventilated.

Concerning the water-supply, it should be noted whether it is supplied from rivers, lakes or springs, wells or cisterns, and whether delivered by wagons or pipes. If the latter, the head of water by day and night. Its sufficiency for cooking, bathing and laundry purposes; its quality, as determined by examination and analysis, and what means for its purification are in use, if such be necessary; its possible sources of contamination with reference to their correction.

The nature and composition of the ration; whether sufficient, properly constituted, of good quality and what facilities are available at the station for its proper variation; its preparation, cooking and method of serving. Whether the ration is economically administered; the size of the company funds and how they are expended. The amount of savings from the flour ration and the quality of bread. The proportion of canned or preserved meats or vegetables used. The character and quality of the fresh meat supplied; whether killed in the vicinity or supplied from cold storage. The nature and qualities of fruits and vegetables employed and their effects upon health. Kitchen and cooking utensils; whether maintained in a cleanly condition and sufficient for variety in cooking; the condition of the dining-room or mess-tent. Whether unrestricted vending by hucksters is permitted. The character of diets used in hospital, their variation, and the manner in which the per diem allowance for each patient is expended. The character of supplies available for this purpose.

Whether the clothing issued for the use of troops is sufficient, of good quality and adapted to the climate; and, if not, what improvement might be made in this respect. The character of the shoes and head-gear.

The nature of the bedding; its sufficiency, general condition and frequency of airing; the improvisation of beds in camp or whether troops are required to sleep on the ground.

The facilities for personal cleanliness available; baths and lavatories, their condition and sufficiency. The cleanliness of the troops and the frequency with which baths are required to be taken. The frequent changing and laundrying of garments and bed-linen; the presence of vermin.

General police; cleanliness within and without habitations; soil contamination, the character and amount of visible filth or refuse, the existence of nuisances. The condition of all dumping-grounds, manure heaps, stables and outbuildings. The camps and surroundings of civilian employees; the location of the picket-lines for public animals. Methods employed for the disposal of refuse; by burial, removal or burning. The disposition of excreta; in earth- or water-closets, by buckets, troughs, pits or cremation. The sanitary state of water-closets; how efficiently flushed.

Condition of latrines; if protected against rain and observation; whether deep or shallow; amount of contents. The frequency with which fresh earth is applied and how often disinfection is practiced. The manner and probable efficiency of the methods directed toward their disinfection. Garbage; its storage, method of removal and manner of disposal. The disposition of kitchen and slop waters.

The habits, methods of exercise and amusements of the men in their relation to health. The prevalence of venereal disease, its causes and the best methods for its diminution or control. The amount of alcoholics used by troops and their effect upon health; the amount of alcoholism and how it may be diminished. The measures in vogue for the decrease of intemperance. The suitability of buildings used as canteens; the quality of provisions sold in them and the amount of liquors dispensed. Whether they are conducted according to the spirit of regulations, and concerning the efficiency of their management. The direct or indirect influence of canteens upon intemperance, disease and crime. The existence of reading-rooms and libraries.

The character of the recruits received and whether due care is employed in their selection. The discipline of the command; the existence of discontent and desertion among the men, and the causes leading thereto. The nature and amount of duty required and its influence on health; the amount of fatigue required in warm climates. The frequency of drills and marches, how long they continue and at what hours they occur. The proportion of nights in bed to those on duty.

Climate in its effect upon the health of troops. The nature, causes, preventability and means of control of diseases occurring most commonly. The relative value of each class of causes inducing disease in troops; the degree to which new arrivals have suffered and the proportion of acclimated troops affected. The prevalence of epidemics and their special seasons. The existence of epidemic disease among the civil population of the vicinity or of the country into which an expedition is to be made; the prevalence of disease in any organizations in excess of the average, and the probable causes therefor. The existing and average proportion of sick, the arrangements for their care and the disposition made of them. The state of vaccination and the extent to which it has furnished a protection against smallpox; the efficiency of the virus employed. The accuracy of diagnosis in cases of yellow fever, smallpox, cholera and plague; the nature of their surroundings, the probable extent to which the disease may have been communicated through the command by the sick, the plan of isolation adopted, the methods of disinfection employed and their probable efficiency.

Regarding the medical officers, hospital corps men and female nurses, the inspector should observe their number with regiments or hospitals, their sufficiency, presence or absence, reason of absence and prospect of return; their activity, competence and attention to duty. The support given medical officers by the combatant force in the efforts of the former to improve unsanitary conditions.

In conclusion, it may be emphasized that while it is the function of the medical officer professionally to treat such cases of disease as may arise, it is his greater duty, as guardian of the public health in the military service, to prevent by watchful foresight, so far as is consistent with the progress of human knowledge, their outbreak and their increase.

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